POWER

A McGRAW-HILL PUBLICATION—ESTABLISHED 1884

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*Volume 70* NEW YORK, SEPTEMBER 3, 1929 *Number 10*

# Courtesy

WE were driving along in a line of cars that had accumulated behind a wide, laboring truck on a hilly, winding road.

The usual manifestations of impatience occurred. The more aggressive dodged out of line and forced themselves in again to their own peril and the discomfiture of those into whose places they crowded.

The attitude, ordinarily, of the slow leader of such a procession is to roll along at his own gait with an air of self-satisfied righteousness born of compliance with the traffic regulations.

But the driver of this truck, as soon as he came to a straightaway where he could see the road ahead, hauled off to one side, slowed up and signaled the cars behind to pass him, waving them on so long as the road was open and holding them back for an approaching car or a blind curve.

The maledictions that had been heaped upon him changed to benedictions and as each car passed its occupants waved or shouted appreciation.

How much more smoothly we should get along if this spirit of helpful courtesy were general instead of occasional.

How many pious, law-abiding citizens plod their way through life, keeping within the law, blocking the road no more than is the custom, but with smug indifference to the presence and progress of their fellow men.

How many refuse to keep in line and wait their turn but forge ahead with reckless self-assertiveness and exaggerated self-interest, acquiring the contumely and contempt of those whom they have bumped aside or crowded to the rear.

And, on the other hand, how many unable or unambitious to keep more than a plodding pace resent being distanced by the better equipped and more progressive, and instead of waving them on make it as difficult as possible for them to get by.

F. R. Low

## POWER *Stands for . . .*

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**

## Instruments and Their Maintenance

INSTALLATION of most of the operating instruments in a power house is usually justified on the basis that they are necessary guides to the operating force and that through their indications efficient operation is accomplished. Undoubtedly this is their major function, but in many cases not the only one.

The maintenance engineer in a power house seldom considers that the operating instruments are of any value to him. Yet if he will but study their indications he can learn much about the condition of the power house equipment that otherwise would go unsuspected.

For example, the boiler meter or other instruments usually installed will tell, if properly interpreted, when the boiler should be shut down for cleaning and whether the baffling is in good condition. Likewise the cleanliness of the condenser can be estimated from the record of load, vacuum and temperature reading. By occasionally analyzing the stage pressures, vacuum and load readings, the condition of the turbine blading can be watched and trouble frequently detected in time to prevent more serious damage. These are but a few of the examples that could be given to illustrate the value of instruments for maintenance purposes.

On the basis of a stitch in time saves nine the engineer who uses the instruments at his disposal can undoubtedly decrease maintenance costs.

## Whose Business Is Power Consumption?

THERE is a very definite opinion abroad in certain quarters that it is not the power engineer's business how power plant products are used in the factory. Unfortunately, in some places this opinion is accepted, with the result that wastes are allowed to go on which make the cost of production unduly high.

For example, consider a certain candy factory where the foreman insisted that he must have ninety-pound steam for his process work. This plant made a change in power engineers, and the new man tried for some weeks to induce the foreman to try exhaust steam. But he was told to mind his business; that it was his job to make what the factory needed and that if the foreman knew from experience that ninety-pound steam was right then the engineer should give it to him.

This new engineer, however, was a persistent man. So he quietly delved into the secrets of candy-making until he was sure just what the steam requirements of each process were. It was evident that exhaust steam would suffice for all plant needs. So he gradually changed over the whole system, nights and Sundays, when the foreman was absent, being careful to make the capacity of the new piping system adequate to give proper service.

Everything went smoothly and no comments were made. The foreman probably thought that the engineer was merely replacing worn-out piping.

About two months after the steam lines had all been placed on the exhaust system the engineer explained what he had done at a factory meeting. The foreman and the management were convinced that the engineer was right, and thereafter welcomed his suggestions.

It is not probable that there are very many other plants in which such striking demonstrations can be made. But it is no doubt true that the power engineer can make savings in any plant if he insists on the most economical use of process steam and other power services.

## International Contacts For Engineers

SCIENCE has always been international—one cubic meter of nitrogen at 760 mm. pressure has a fixed mass, here or in China. Engineering, on the other hand, combining science and business, has been largely national—the engineer deals with definite machines made in a definite country, and not merely with matter in the abstract. Thus it is but natural that international contacts of engineers have been less complete than those of their scientific brothers. Nevertheless, engineers have much to gain by closer contacts with fellow workers in foreign countries.

A distinct advance in this direction is evident in recent and coming events. In July steam table specialists from several countries, including a prominent delegation from America, gathered at London and achieved marked progress toward international standardization. World Power Conference sectional and general sessions in London, Barcelona, and soon in Tokio, integrate the engineering thought of the whole civilized world. The World Engineering Congress this fall in Tokio brings the Orient into the international engineering picture.

Those fortunate enough to participate personally in these events must necessarily achieve a broader viewpoint and become bigger and better engineers because of it. Those who stay at home profit by reading reports of the meetings and by contact with the travelers.

All in all, it is clear that engineering is passing from the national into the international phase and that engineering progress must therefore be still more rapid and sound in the future.

## The Supervisory Engineer

IN VIEW of the exacting demands of modern business, it is now common for business men to have their health checked up periodically, without waiting for symptoms of impending disorder.

If this is good practice for the human power plant, why is it not equally essential to the mechanical plant?

A power plant may continue to render creditable service from day to day, without any signs of trouble and apparently with good efficiency. The operating engineer is probably competent and knows the details of his plant as no outsider could. Yet routine duties may be keeping him too close to the picture.

The outside consultant, on the other hand, has the advantage of a detached viewpoint and a background of experience accumulated from the problems of many other plants operating under a variety of conditions. This experience will often enable him to make suggestions for improvements or to spot impending trouble that would not be apparent to the engineer on the job.

There was a time when the operating engineer resented the presence of the advisory engineer. This may have been due partly to a suspicion that his prerogatives were being "stepped upon," and partly to lack of tact on the part of the outside engineer. Happily, this situation now rarely exists, and there is a disposition on the part of the operating man to regard the consulting engineer as a counselor and an ally in getting across to the management the need for essential improvements.

## Highways and Horsepower

YEAR BY YEAR the web of concrete threads—the improved highways—spreads out, tying community to community and bringing into contact with the busy modern world whole districts that were previously isolated. Swift trucks and buses operating on these roads have brought adequate transportation to places formerly largely unaffected by changing conditions.

Many things follow upon this development, two of which are having a far-reaching influence in the power field. Consider how the consuming habits of great stretches of territory are changed. People whose wants until recently were but simple and few now buy as large a quantity of as wide a variety of goods as do dwellers in the most highly developed centers. This increases industrial markets, enlarges factory output, makes for greater prosperity and a greater demand for power.

In addition these highway systems tend to decentralize industry. It has become not only possible, but advisable, to locate factories in regions formerly wholly agricultural. Because of this, extensive networks of transmission lines are rapidly spreading to cover every part of the country. These serve the new industrial populations and many of the industries. But at the same time many new plants are being built by industries that find it economical to generate their own power because of process steam or other service requirements.

Taken together, the results of these changes are an increased use of power and a better market for power equipment. Also the opportunities for power engineers are improved. It would have been hard to foretell this in the days when the increasing popularity of the automobile was forcing highway development. Nor is it possible to forecast what new factors of today—as air transport—may mean in the power development of the next ten years.

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It is not surprising that the first real main-line Diesel locomotive on this side of the Atlantic should be placed in operation on a railroad in Canada. Unhampered by the conservativeness of the older railroads, the Canadian Northern proved the feasibility of operating Diesel rail cars, and has now produced a two-unit Diesel locomotive of about three thousand horsepower output. The successful tests just completed should be examined closely by the mechanical engineers of other railroads, for the main-line Diesel locomotive is at least one solution of the problem of lower operating costs.

* * * *

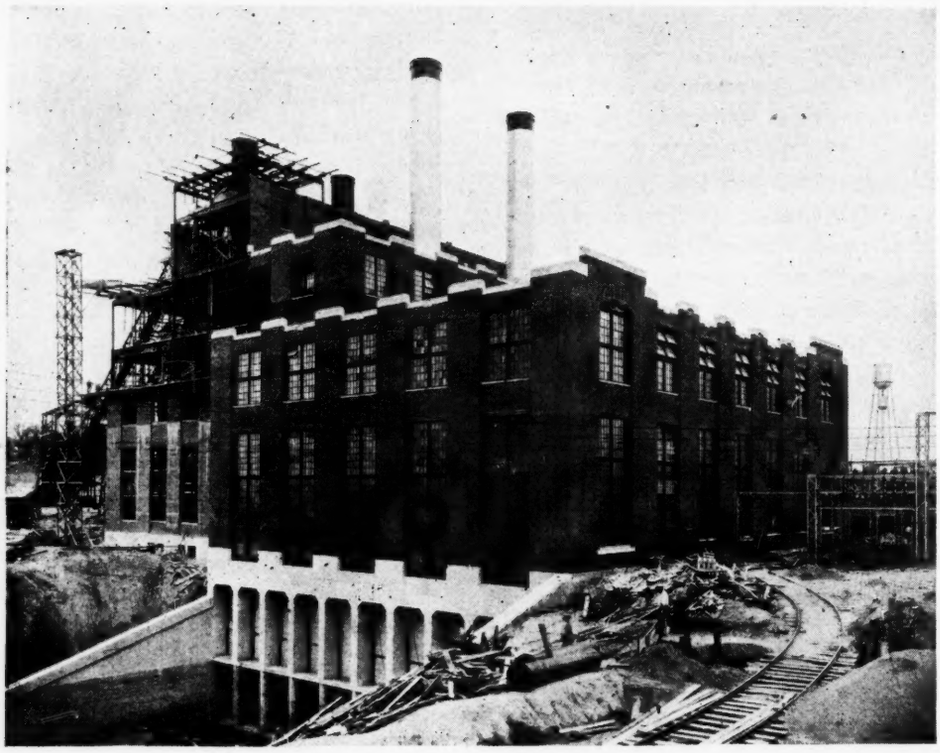
It is significant that the program of the coming Fall Meeeting of the American Welding Society includes two papers on new non-destructive tests of welds. The welding people have repeatedly declared that proper procedure control and inspection make good welds certain. This statement seems to be founded on fact. Nevertheless, some will be satisfied with nothing less than a "test" of the finished weld—a test that leaves the weld intact. Whether or not such demands are reasonable, ability to meet them must increase the fast-growing public confidence in welding.

* * * *

The field of energy interchange between industrial plants has hardly been touched in this country. In Germany and other European countries, such interchange is an established practice, working, apparently, to the mutual advantage of the central stations and the private plants. Large steel and chemical plants can often generate large blocks of excess power as a byproduct. Sale of such current to the utility at a rate higher than the generating cost of the private plant and lower than that of the utility must benefit all concerned.

* * * *

There is a widespread feeling among designers of stationary plants that the marine field is "missing a bet" in not following land practice in the adoption of high steam pressures. Perhaps they are, but those most familiar with the practical side of marine work claim that the difficulty of maintaining tight joints with high pressures, in the face of the vibration and weaving encountered on shipboard, more than offsets the advantages of such pressures.



# Engineering Requirements
## *That Determined the Design of the*
# Riverbend Power Plant

By D. NABOW
*Mechanical Engineer, Duke Power Co.*

THE latest power plant constructed by the Duke Power Company is the Riverbend Steam Station. This plant is located on the Catawba River, near Mount Holly, N. C., which is the load center of the extensive Duke high-tension transmission system.

The present installed generating capacity of the system is as follows:

| | |
|---|---|
| Water power stations owned, kva | 610,000 |
| Water power stations leased, kva | 48,000 |
| Total water power stations, kva | 658,000 |
| Steam stations owned (not including Riverbend Steam Station), kva | 218,000 |
| Steam stations leased, kva | 27,000 |
| Total steam stations, kva | 245,000 |
| Total water power and steam power, kva | 903,000 |

More than 4,000 miles of lines, covering the entire Piedmont section of North and South Carolina and serving approximately 250 communities with a population of about 3,000,000, is embraced in this system. More than half of the cotton spindles of the Carolinas, or approximately 20 per cent of all the active spindles in America, are driven by power from this system, which also supplies power to hundreds of textile specialty plants, hosiery mills, furniture factories, flour mills, tobacco factories and various other industries which have been developing at so remarkable a rate in Piedmont Carolinas during the past two decades.

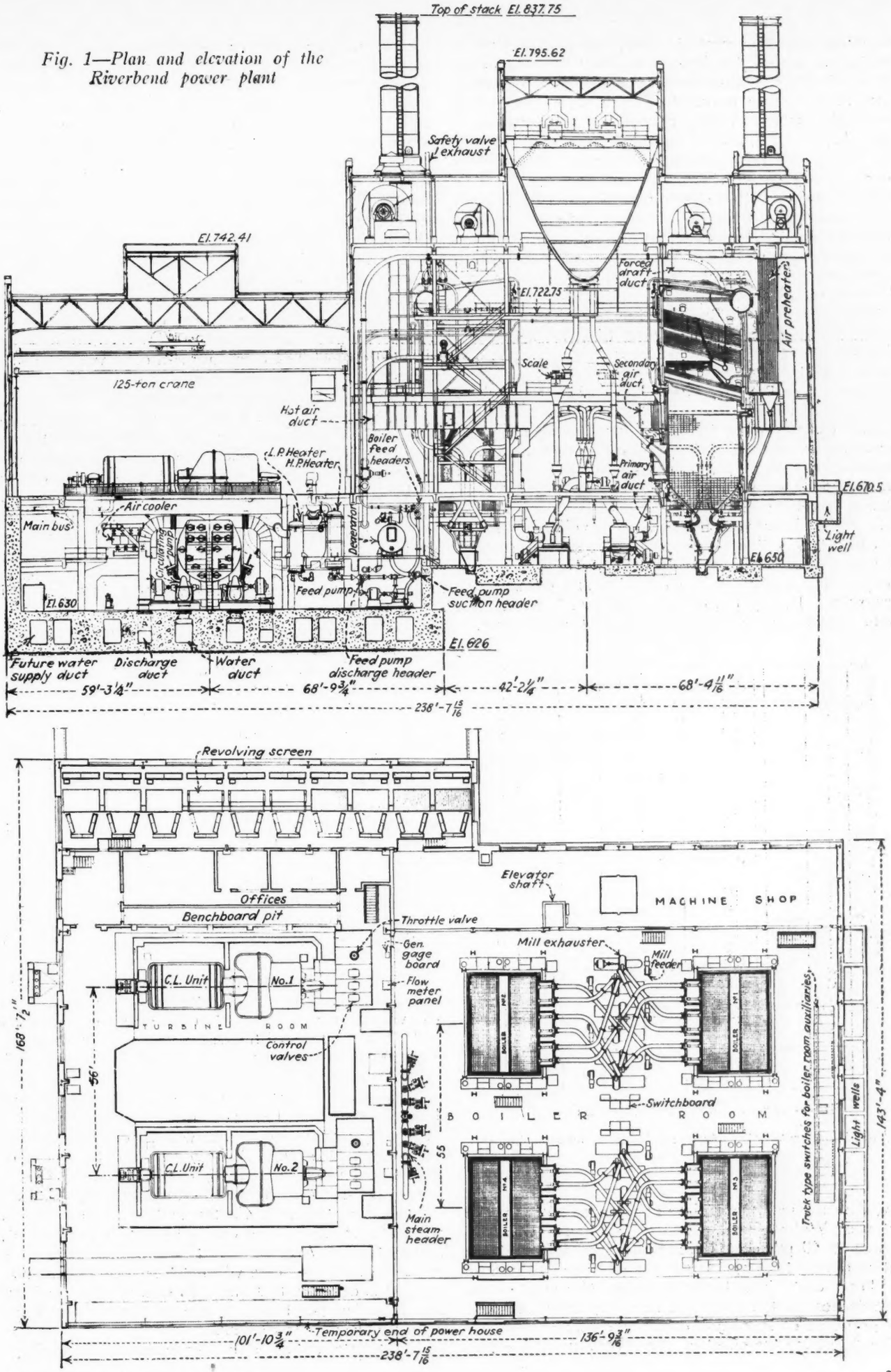
The Riverbend Steam Station, with its initial installation of 137,000 kva., brings this total to over 1,000,000 kva. It also increases steam station capacity to a point where it is equal to over 50 per cent of the installed capacity of the water power stations and thus assures continuity of the power supply even during extreme periods of drought, such as that of 1925-27.

The building of this station is in line with the policy of the company to combine efficient steam stations with the intensive development of the water power resources.

Because of its strategic location in the heart of the distribution system, the Riverbend Steam Station has been designed for an ultimate installation of 450,000 kva. The present installation consists of two 55,000 kw. units, or approximately one-fourth of the ultimate installation. The condenser water intake and discharge canals, discharge tunnel and the coal-handling structures have been built for the ultimate installation.

The ultimate requirement of more than 500,000 gal. of condensing water per minute during the period of

*Fig. 1—Plan and elevation of the Riverbend power plant*



minimum river flow presented an interesting problem in location on a river the flow of which is controlled by a series of twelve hydro-electric stations, most of which back headwater to tailwater. The river is, in fact, a series of reservoirs having a combined surface area of about 50,000 acres, and during the dry period of the year the flow at any point depends entirely on the operation of the water power stations immediately upstream or downstream, or both. It was desired to find a location which would permit the full operation of the ultimate installation without loss due to recirculation, even when the water power stations both upstream and downstream of the steam stations were shut down over night or over the week end.

Such an ideal location was found about two miles above the Mount Island Hydro Station, where the Catawba River makes a deep horseshoe bend. The distance along the horseshoe is over seven miles, while the distance across the ends is less than a half mile. The reservoir area in the bend is over 1,800 acres and the storage capacity more than eight billion gallons. The power house, intake and discharge canals and tunnel are located in line across the narrow neck of the bend. The drainage area of the Catawba River at Mount Island Station is 1,800 square miles.

Since the Riverbend Steam Station will be operated in connection with an extensive hydro-electric system, its annual load factor and the distribution of load during the year will be influenced by rainfall and the stage of reservoirs. During the operating season, however, the units in operation will carry full rated load 24 hours a

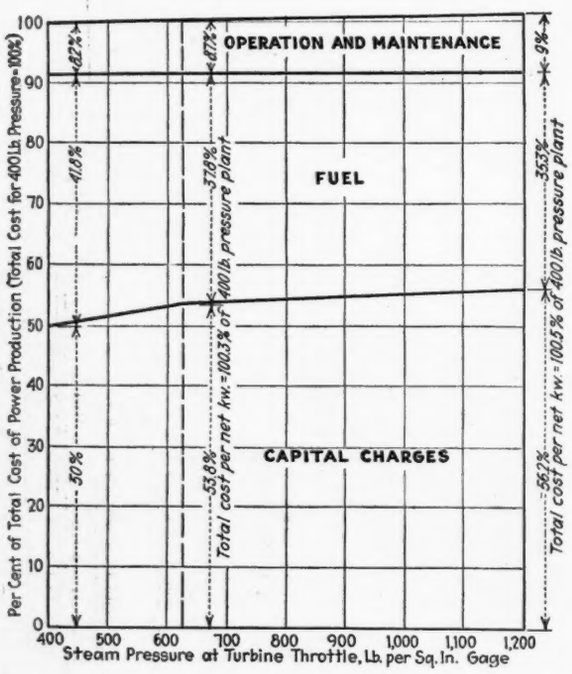



*Fig. 2—Comparative total costs with various boiler pressures*

day, the daily load fluctuations being taken by the hydro stations. While the mean annual load factor was considered as 40 per cent, the monthly load factor of the station during the dry fall months will be anywhere up to 100 per cent. This factor influenced to a great extent the selection of the main and auxiliary equipment and the provision of spare and duplicate equipment.

To determine the effect of steam pressure at the turbine throttle upon the coal consumption, upon the cost of installation and upon the total cost of power production, comparative studies, layouts and estimates were made for steam plants designed for 400-lb., 625-lb. and 1,200-lb. gage pressure and 725 deg. F. Four-stage bleeding was considered for each pressure, and single-stage reheating was considered for the 625-lb. and 1,200-lb. pressures. To make these studies truly comparable, an installation of two 50,000-kw. turbine-generator units was considered in each case. For the 1,200-lb. pressure, each unit consisted of an 11,700-kw. high-pressure turbine operating at 3,600 r.p.m. and a 38,300-kw. low-pressure unit operating at 1,800 r.p.m.

The steam generating, condensing and auxiliary equipment was selected on as nearly an equal basis as possible. A separate plant layout was made for each pressure, and detailed estimates of quantities and costs were made for the structures, main and auxiliary equipment and the electrical switching station and apparatus.

The results of these studies are shown on Fig. 2. It will be noted that while the fuel consumption is 9.7 per cent lower for the 625-lb. pressure and 15.6 per cent lower for the 1,200-lb. pressure, the saving in cost of fuel is entirely absorbed by the increase in capital charges, thus canceling any economic advantage of the higher pressures. The 400-lb. pressure had the additional advantages that it involved the lowest initial cost and permitted complete interconnection of the boilers, thus increasing the flexibility of the installation.

In the final design, 425-lb. gage pressure and 725 deg. F. temperature at the turbine throttle were used.

A power house cross-section and plan are shown in Fig. 1. It will be noted that each 55 ft. length of power house contains all the main and auxiliary equipment of one complete generating unit.

The boilers are arranged in two rows, with the coal bunkers, pulverizing and conveying equipment located between the boilers in the center of the boiler room, which is 135 ft. wide.

The turbines are located crosswise in the turbine room, which is 100 ft. wide. The condensers are arranged to face each other, with all the circulating pumps located between the turbines and accessible to the power house crane. The west end of the power house is arranged as a service bay, and houses the control switchboard, main offices, machine shop, laboratory, store room, station heating boiler, surge tanks and all station service equipment.

Most of the coal used at this station will come from mines in West Virginia, Kentucky and Tennessee and will vary from run of mine to mine dust. It is expected that a good portion of the coal consumed will be screenings, available in the late summer and fall when coal is being prepared for domestic consumption.

To permit complete freedom in purchasing of coal, generous provisions have been made for both unloading, conveying and storing. Coal will be delivered by the Piedmont & Northern Railway and will be placed on yard tracks having a capacity of 60 cars. An electric locomotive will place the cars on a 52-ft. revolving car dumper mounted on a 400-ton scale. The empty cars will be "bumped off" and will go by gravity to the empty storage tracks. A run-around track is provided so delivery and removal of cars will not interfere with unloading. It is expected that about 15 cars could be weighed and unloaded per hour. There is also an emergency manual unloading track hopper.

A duplicate system of belt conveyers, each having a

capacity of 300 tons per hour, carry the coal from the unloading hopper to the crusher house and then to the junction house. From here the coal can be dispatched to either the power house or the storage field. The conveyors from the reclaiming hopper in the storage field also enter the junction house and are arranged to discharge into the conveyors to the power house. These conveyors are equipped with weightometers and magnetic separating pulleys. By cross-connected chutes these conveyors discharge onto others equipped with automatic trippers to discharge the coal into the bunkers above the boiler aisle.

The entire coal-conveying and crushing system is electrically interlocked, with the controls located in the junction house. Special attention has been paid to dust-tightness at points of delivery and at the crushers.

2. It eliminates coal driers, air washers, cyclones, pulverized-fuel bunkers and most of the coal-conveying equipment, thus tending to reduce operation and maintenance costs.

3. It permits a more compact and satisfactory plant layout.

Each of the four steam-generating units is served by three 10-ton air-separation type gear-driven pulverizer mills, located in front of each unit in the boiler room basement.

Coal flows by gravity from the overhead coal bunkers through automatic coal scales (on one boiler only) and is fed to each pulverizer by a drag-chain feeder driven by a variable-speed direct-current motor. The feeder speed will be regulated approximately in parallel with the mill speed and will be automatically readjusted by a

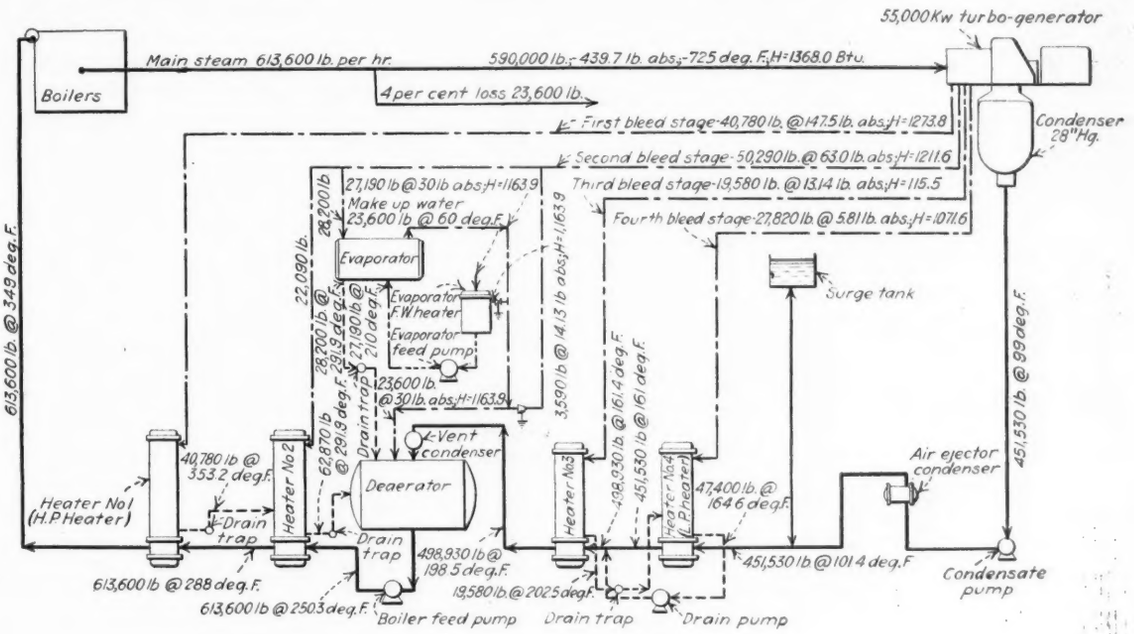

55,000 Kw turbo-generator
Main steam 613,600 lb. per hr.
590,000 lb.; 439.7 lb. abs.; 725 deg. F.; H=1368.0 Btu.
Boilers
4 per cent loss 23,600 lb.
First bleed stage-40,780 lb. @ 147.5 lb. abs.; H=1273.8
Condenser 28" Hg.
Second bleed stage-50,290 lb. @ 63.0 lb. abs.; H=1211.6
Third bleed stage-19,580 lb. @ 13.14 lb. abs.; H=1115.5
Fourth bleed stage-27,820 lb. @ 5.811 lb. abs.; H=1071.6
27,190 lb @ 30 lb abs.; H=1163.9
Make up water 23,600 lb @ 60 deg. F.
28,200 lb.
22,090 lb.
Evaporator
Evaporator F.W. heater
Evaporator feed pump
Surge tank
613,600 lb. @ 349 deg. F.
28,200 lb @ 29.9 deg. F.
27,190 lb @ 210 deg. F.
123,600 lb. @ 30 lb. abs.; H=1163.9
Drain trap
3,590 lb @ 14.3 lb abs.; H=1,163.9
Vent condenser
Deaerator
40,780 lb @ 353.2 deg. F.
62,870 lb @ 29.9 deg. F.
Heater No. 2
Heater No. 3
498,930 lb @ 161.4 deg. F.
451,530 lb @ 161 deg. F.
Heater No. 4 (L.P. heater)
47,400 lb @ 164.6 deg. F.
Air ejector condenser
451,530 lb @ 99 deg. F.
Heater No. 1 (H.P. Heater)
Drain trap
Drain trap
498,930 lb @ 198.5 deg. F.
451,530 lb @ 101.4 deg. F.
Condensate pump
613,600 lb @ 288 deg. F.
19,580 lb @ 202.5 deg. F.
613,600 lb @ 250.3 deg. F.
Boiler feed pump
Drain trap
Drain pump

*Fig. 3—Heat-balance diagram of the plant*

Provision has been made in all the coal-handling structures for the installation on a third conveying and crushing system to take care of the ultimate installation when the addition is needed.

Two drag scrapers, each having a capacity of 300 tons per hour at a radius of 135 ft., are used for storing and reclaiming coal. The capacity of the storage field is 140,000 tons, considering a mean depth of 20 ft. It may be interesting to note that the Duke Power Company has four other similar drag scraper installations, which have been in operation from three to seven years, storing crushed coal up to 30 ft. in depth without a fire of any consequence.

The two coal bunkers in the boiler room are of the plate-steel suspension type, each having a capacity of 1,200 tons. This is equal to the 24-hr. requirements of the two boilers served by each bunker.

Pulverized-fuel firing was decided on after a review of the two years' operation and maintenance of this method of firing at the Buck Steam Station. Bids were received for both the "storage" and "direct-fired" systems. After a careful study of the proposals and of existing installations, the direct-fired system was selected because of its advantages, namely:

1. It costs less to install.

coal-level indicator paddle suspended above the moving coal bed.

Preheated primary air, which is used for both drying the raw coal and conveying the pulverized fuel, is drawn into each mill by a paddle-wheel exhauster fan having a capacity of 15,000 c.f.m. at 12-in. s.p. The air flow through the mill will be maintained constant at practically all loads to obtain uniformity of fineness of coal. Regulation of air for proper combustion will be effected by controlling the secondary air, which forms the greatest portion of air used.

The guaranteed fineness of pulverization of each mill is given in the tabulation:

FINENESS OF PULVERIZATION

| Mesh of screen.... | 200 | 100 | 80 | 40 |
|---|---|---|---|---|
| Output, tons per hr. | Per Cent Passing Screen | | | |
| 5..... | 75 | 90 | 94 | 99.8 |
| 10..... | 70 | 85 | 92 | 99 |

When delivering five tons per hour the mills, exhausters and feeders are to consume not over 12 kw. per ton, and not over 10.5 kw. per ton when the output is 10 tons per hour.

In the selection of the steam-generating equipment, the boiler, furnace, superheater, air preheater and pulverized-fuel burners were considered as a unit, each com-

ponent part being proportioned to give a well-balanced economically efficient installation. Four steam-generating units were installed, three of which can supply the full load steam requirements of the station. Each steam generating unit consists of a boiler, superheater, furnace, air preheater and coal burners. Each of the sectional cross-drum boilers has an effective heating surface of 35,500 sq.ft., made up of 51 tube sections, 24 tubes high. The drum is 72 in. in diameter, is $2\frac{1}{8}$ in. thick and is designed for 500 lb. working pressure. The boilers are equal to the largest yet built for high-pressure service.

The interdeck superheater has a heating surface of 6,600 sq.ft. and is connected to the boiler drum by 18 four-inch tubes. The tubular air preheater has an effective heating surface of 56,000 square feet.

Both side walls, uptake and downtake walls, totaling 2,352 sq.ft., and the floor are lined with water tubes covered with bare metal blocks. At maximum load the heat liberation will be 30,000 B.t.u. per hr. per cu.ft. of furnace volume.

Each boiler is equipped with two intertube burners, two of which are fed by each pulverizer. These burners are so arranged that balanced combustion conditions are obtained with one, two or three mills operating per boiler.

The initial installation consists of two single-cylinder condensing turbine-generators, designed to operate at 1,800 r.p.m., with 425-lb. gage steam pressure and 725 deg. F. total temperature at the turbine throttle, with four-stage bleeding. Normally each unit will be operated at 55,000 kw., which is essentially the most efficient load for the turbine, at the mean back pressure of 1.5 in hg. abs. These are in the course of erection and are shown in Fig. 5.

With the primary, secondary and tertiary valves wide open and with the same back pressure, each unit has a maximum capacity of 62,000 kw. The generators deliver 3-phase, 60-cycle, 13,200-volt current. The excitation is provided by a 200-kw. 250-volt shunt-wound direct-connected exciter, with motor-operated rheostat control.

The speed governor is of the recently developed impeller-type oil pump, mounted on the governor end of the turbine shaft. The oil pressure, which varies with the turbine speed, actuates a pilot valve which controls the hydraulic valve gear and the steam admission valves. In case of instantaneous loss of total load, the governor mechanism is guaranteed to act with sufficient speed to avoid tripping of the throttle valve by the emergency governor.

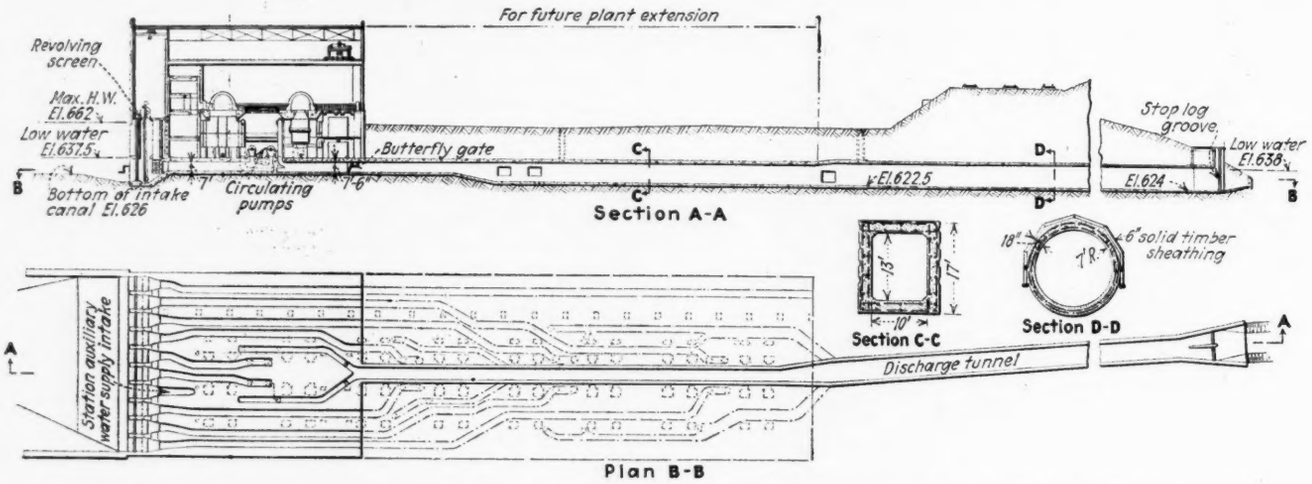



*Fig. 4—Condensing water is taken from the river and is discharged into a tunnel leading back to the river*

Each steam-generating unit has a capacity of 450,000 lb. of steam per hour delivered at the superheater outlet at a pressure of 450 lb. and at a temperature of 750 deg. Fahrenheit.

The forced-draft equipment consists of one single-wheel, turbovane fan per boiler. Each fan was designed for a maximum capacity of 128,000 c.f.m. at a static pressure of 9.4 in. and is driven by a 300-hp. constant-speed induction motor arranged for "across-the-line starting." Considering the uniform load to be carried by the boilers, the drive was found to be efficient as well as simple and economical. Volume control is effected by means of movable inlet vanes, which are operated by direct-current motors with push-button control from the boiler room benchboard.

Each induced-draft fan has a maximum capacity of 262,000 c.f.m. at a static pressure of 11.7 in. The same constant-speed type of motor drive, of 850 hp., and the same type of volume control are used as for the forced-draft fans. Each fan discharges directly into an 11-ft. diameter stack, eliminating all breechings. It will be noted that there are practically no flue ducts between each boiler and its stack. Also there are no dampers, except for the inlet vanes on the fans.

Ventilation for the generator is provided by internal fans mounted on the rotor. A closed ventilating system is used, the air coolers being connected into the condenser circulation system.

The guaranteed performance of each unit, with four-stage bleeding, is: For a load of 55,000 kw. at 1 in. back pressure, 10,550 B.t.u. per kw.-hr.; at 1.5-in. back pressure, 10,800 B.t.u., and at 2-in. back pressure, 11,110 B.t.u.

The heaviest operating period for this station will be in the late summer and early fall months, when the river flow is usually low. Even without any recirculation, mean monthly temperatures of 82 deg. F. are expected. Proposals were received for both single- and two-pass condensers, with several different combinations of surface areas and condensing water quantities. The equipment selected consists of two 60,000 sq.ft., two-pass units of the divided waterbox type, with two circulating pumps per unit, each having a capacity of 36,000 g.p.m. The capacity of each pump required for condenser operation is 34,000 g.p.m., the excess capacity being for the generator air coolers and turbine-generator oil coolers. The condensate is removed by duplicate two-stage 1,000-g.p.m. centrifugal hotwell pumps, and two two-stage steam-ejecter type air pumps are provided for air removal.

The condensing equipment is guaranteed to deliver condensate with an oxygen content of less than .04 c.c. per litre and at a temperature not more than 1 deg. F. below the steam at the turbine exhaust connection to the condenser.

The heat-balance diagram, Fig. 3, shows the essential features of the four-stage feed-water heating, deäerating and make-up water evaporating systems. While the arrangement as shown is highly efficient, it does not include the circulation of the condensate through the generator air and oil coolers, which could not be economically justified.

When the make-up water system is not in operation, the feed water is heated in four closed heaters and one contact-type deäerating heater to 349 deg. F. The condensate from heater No. 1 is trapped into heater No. 2 and from there, together with the condensate of heater No. 2, it is trap-drained into the deäerating heater. The condensate from heater No. 3 is trapped to heater No. 4, and together with the condensate of heater No. 4 is pumped into the feed line ahead of the low-pressure heater. The upper surge tank, which floats on the line ahead of the condensate pumps, is located at an elevation sufficient to force water into the deäerating heater and insure a supply of water to the boiler-feed pumps.

When the evaporating system is in operation the deäerator acts as a vapor condenser. The raw river water used for make-up is slightly alkaline, with practically no scale-forming salts. However, it carries as much as 400 parts per million of total solids, most of it being silt in colloidal suspension. The evaporating equipment selected for each unit consists of an open feed-water heater in which the raw water is heated to just below the boiling point, precipating most of the silt. Evaporation takes place in a film-type evaporator with an external settling hotwell.

Three motor-driven and one turbine-driven, five-stage, centrifugal boiler-feed pumps were installed, each having a capacity of 650,000 lb. per hr. at a net discharge pressure of 560 lb. Only two of the pumps will be in operation at full station load. All the pumps are interconnected on both the suction and discharge side, so any pump can be used for either unit.

## The Piping Systems

The main piping systems are arranged for complete interconnection of the boilers. However, the station can be segregated and operated as two distinctly separate units, without any interconnections.

All high-pressure steam and feed-water lines are of seamless drawn steel tubing with Van Stone serrated face flanged joints, conforming to the A.E.S.C. 600-lb. standard.

Bolts for the high-pressure steam and boiler-feed lines are of "Class C Alloy-Steel Bolting Material for High Temperature Service," as given in A.S.T.M. specifications, Serial Designation A-96-27. The bolts are threaded their full length and the nuts are hot forged and cold pressed to the United States Government's standard.

All the high-pressure gate valves are trimmed with nitroloy and all the gate valves in the boiler leads, turbine leads and steam header are motor operated.

Each boiler has one superheater steam outlet, which is arranged so that all the steam leads to the main steam header are located in the central cross aisle. The boiler steam leads are 14 in. in diameter between the near boilers and the steam header and 16 in. between the far boilers and the steam header to equalize the pressure drop between all boilers and the steam header.

The steam header is of cast steel, in two sections, with a sectionalizing valve between. Each section is 13 ft. 6 in. long, 21½ in. o.d., tapering at each end to a 14-in. flanged connection, and is 1¾ in. thick. This header has been constructed in accordance with A.S.T.M. Tentative Specification, Series Designation A-95-26-T and A.E.S.C. American Standard for Steel Pipe Flanges and Flanged Fittings, for a maximum working steam pressure of 500 lb. per sq.in. and a total steam temperature of 750 deg. F. The header supports and anchor are welded to the header.

The feed-water header is installed in duplicate and each of the two feeders per boiler is connected to both headers.

## No Atmospheric Relief Valves

The atmospheric relief valves, for protection of the turbines, and the attendant cumbersome piping have been omitted and automatic vacuum trippers have been installed. Rupturing diaphragms, designed to blow out if the tripper should fail to handle overpressure, have been installed on the atmospheric exhaust outlets of the condensers.

The low-pressure heaters were located as near as possible to the bleeder outlets. All bleeder piping was designed so the pressure drop between the turbine and the heaters is equivalent to a temperature drop of two deg. F. for all loads.

There is a valved crossover connection between the discharge piping of the two circulating pumps on each condenser. As a result, one pump can furnish water to both sides of the divided waterbox of the condenser when water temperatures or load conditions permit.

The intake canal, intake structure, discharge tunnel and discharge canal, Fig. 4, have been built for the ultimate requirement of about 550,000 g.p.m. The intake structure, which is completely inclosed, houses the racks, traveling screens and gates for ten intake ducts, eight of which will furnish water for condensers and the other two will supply the station service pumps and will also serve as spares. An overhead 20-ton crane will be used to operate the racks and gates and to handle the screens for inspection and repair. Three intake sections will be used for the present installation and three Link-Belt traveling screens have been installed. They are designed to withstand a head differential of five feet.

The intake ducts form a part of the turbine room substructure. The two nearest central ducts are used for the present units and their place is then taken by the discharge ducts.

The discharge tunnel is 14 ft. in diameter and almost 1,100 ft. long. It was driven through a soft, water-bearing, disintegrated granite formation, using 6-in. solid sheeting. The concrete tunnel lining is fully reinforced to resist the direct and bending stresses due to both internal and external loading.

Each section of the waterway was studied separately with the view of getting the highest hydraulic efficiency that could be economically justified. The maximum velocities for the ultimate installation, considering a 10-ft. drawdown of the reservoir are: Intake canal, 1.7 ft. per sec.; racks (gross area), 1.0 ft. per sec.; intake ducts, 5.0 ft. per sec.; discharge tunnel, 8.0 ft. per sec., and discharge canal, 3.5 ft. per sec.

The only portion of the main electrical equipment located inside the power house consists of short sections of the main generator and neutral leads which are taken

from the generator terminals directly to the outdoor switching structure, adjacent to the power house. All other low- and high-tension buses and switches and all main and station auxiliary transformers are located outdoors.

Control of the low-tension bus system of the generating units is centralized in a benchboard located on an elevated platform at the west end of the turbine room. The control of all high-tension equipment is centralized on a vertical board located on the same platform. Provision is made to extend these switchboards to take care of the complete future installation. All relays and exciter field rheostats are on a floor directly below the benchboard platform.

As there is no house turbine at the Riverbend station, two auxiliary banks, each consisting of three 2,500-kva. transformers connected 13,200/2,300 delta delta are installed for feeding the primary auxiliaries. Under normal operating conditions each bank is supplied directly by its generator and feeds the primary auxiliaries of that unit plus the combustion equipment for two boilers.

In addition, a 13,200-volt power-supply line is brought in from the Mountain Island hydro-electric station, two miles downstream, for the independent operation of the auxiliaries in cases of emergency or for starting up.

Secondary auxiliaries are fed from a bank of three 750-kva. transformers connected 13,200/575 volts, delta delta. This bank can be fed from either bus section.

All station auxiliaries, with the exception of a single boiler-feed pump and the turbine-oil pumps, are motor driven.

All motors for the coal-handling system, except for the coal crushers, are 550 volt totally inclosed, squirrel cage, high torque, induction, designed for full-voltage starting. The crusher motors are of the high-torque slip-ring type, with full automatic starting control.

Solenoid-operated circuit breakers, with remote push-button control at operating points, are on the first floor of the junction house, controlling all coal-handling equipment. This includes control of the car dumper, crusher equipment, conveying system and drag scrapers. A complete interlocking scheme is provided for the coal-handling equipment.

The control of all the boiler room auxiliaries is centralized on the boiler room switchboard, which consists of one bench-type control panel and one vertical panel for each boiler, located at the center of the main operating floor in the boiler room. The vertical section of the bench-type control panel contains the necessary boiler meters and gages. The bench section contains the speed control for the pulverizer mills and mill feeders, the vane control for one forced- and one induced-draft fan and the necessary emergency trips for a complete boiler. The vertical panel contains the start and stop buttons and signal lamps for the induced- and forced-draft fans, the pulverizer mills, the mill exhausters and mill feeders. On this panel are also the speed indicators for the pulverizing mills and mill feeders.

All boiler-feed pumps, circulating pumps, condensate pumps and high- and low-pressure water service pumps are driven by 2,300-volt squirrel-cage, drip-proof, full-voltage starting induction motors, controlled by manual- or remote-control circuit breakers in steel truck-type switchboards situated in the turbine room basement.

A 200-kw. 250-volt motor-generator set supplies the direct current for the power house cranes. Direct current for the mill feeders, magnetic separators and vane-control motors is normally supplied by a 75-kw. 250-volt motor-generator set. In case of failure of voltage on this set, the equipment is automatically thrown on storage batteries, which can carry the entire load for three hours. One storage battery with a floating motor-generator set is provided for the switchboards in the turbine room, and a separate battery with a floating motor-generator set is provided for the control of the direct-current equipment in the boiler room. The electrically operated valves in both the turbine and boiler rooms are operated from the turbine room storage battery, emergency closing stations for the simultaneous closing of all valves being in the boiler room. An emergency lighting system is automatically thrown on the storage batteries in case of failure of the normal lighting supply. It is automatically restored when the normal lighting supply is re-energized.

A complete interphone system is provided for communication between all points in the station. A stand-by signal system is so arranged that it can be operated by a push-button station at each telephone.

The boiler room, turbine room, intake structure and

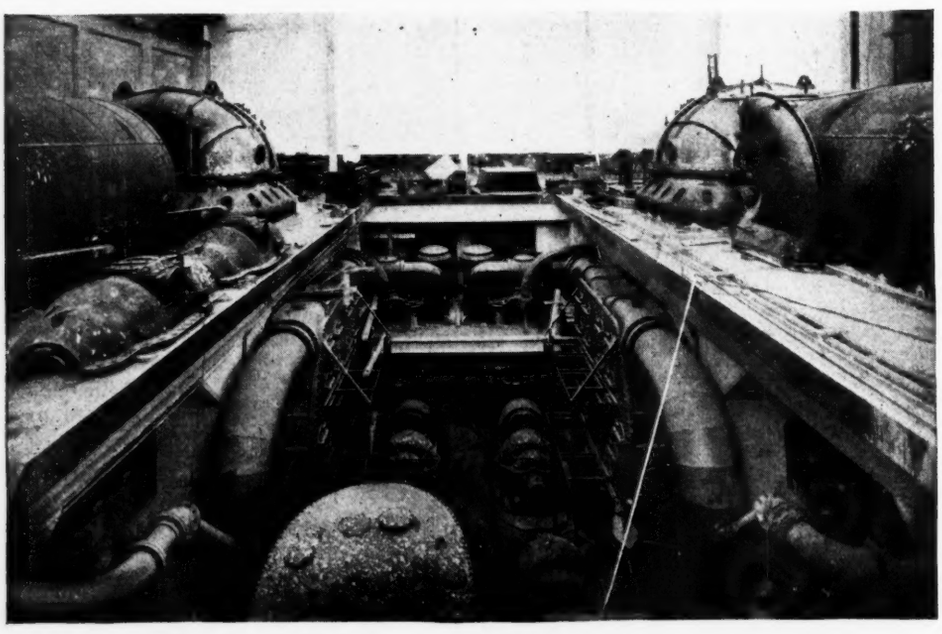


*Fig. 5—The turbine room during erection, showing the machines and condensers*

service bay form one power house structure. The substructure is of reinforced concrete built on a soft disintegrated granite formation.

The boiler room basement is above the normal water level, and the column loads, which are as high as 1,800,000 lb. per column, are carried on spread footings. The turbine room and intake structure basements are formed of a continuous massive slab designed to resist uplift. The superstructure is of steel skeleton frame construction with rough texture red face brick with stone trim. While no effort was made for architectural elaboration, the main building lines have been emphasized, producing a pleasing appearance.

The turbine foundations are of massive concrete construction thoroughly reinforced and rigidly braced to resist the stresses due to both the vertical loading and vertical and horizontal impact, with a maximum deflection of less than 0.025 inches.

The Riverbend Steam Station was designed and built by the Engineering and Construction Departments of the Duke Power Company, under the direction of W. S. Lee, chief engineer and vice-president.

## Principal Equipment in the Riverbend Steam Station of the Duke Power Company

### Boiler Equipment

Boilers, four, sectional cross-drum, 500 lb. water-tube, 35,500 sq.ft. each....Babcock & Wilcox Co.
Superheaters, four, interdeck convection type, 6,600 sq.ft. each, designed for 750 deg. F. outlet temperature .....Babcock & Wilcox Co.
Furnaces, four, 3,352 sq.ft. exposed wall surface, 19,950 cu.ft. volume, with Bailey bare metal blocks .....Fuller Lehigh Co.
Pulverizing mills, three per boiler, 10 tons per hr. each, air-separation direct-feed type, driven by 150-hp. 720-r.p.m., 2,300-volt G.-E. motors .....Fuller Lehigh Co.
Mill feeders, three per boiler, drag-chain type driven by 2-hp. 1,800-r.p.m. 250-volt d.c. G.-E. motors .....Fuller Lehigh Co.
Exhausters, paddle-wheel type, driven by 60-hp. 1,200-r.p.m., 2,300-volt G.-E. a.c. motors .....Fuller Lehigh Co.
Burners, six per boiler, Calumet type..Fuller Lehigh Co.
Forced-draft fans, one per boiler, turbovane type, 128,000 c.f.m., 9.4 in. s.p., driven by 300-hp. 1,200-r.p.m., 2,300-volt G.-E. motors .....B. F. Sturtevant Co.
Induced-draft fans, one per boiler, turbovane type, 262,000 c.f.m., 11.7 in. s.p. driven by 850-hp. 720-r.p.m. 2,300-volt G.-E. motors .....B. F. Sturtevant Co.
Stacks, four 11x75 ft., unlined steel .....International Combustion Engineering Corp.
Breechings and flues, International Combustion Engineering Corp.
Pressure-reducing valves .....Fisher Governor Co.
Feed-water regulators .....Swartwout Co.
Soot blowers .....Diamond Power Specialty Corp.
Safety valves.....Consolidated Ashcroft Hancock Co.
Blowoff valves .....Yarnall-Waring Co.

### Coal-Handling Equipment

Car dumper, one, 52-ft. 100-ton four-clamp revolving-type, driven by 60-hp., 1,800-r.p.m. 550-volt G.-E. motor..William-Seaver-Morgan Co.
Dump scale, 400-ton capacity..Standard Scale & Supply Co.
Coal Crushers, two, 300-ton hammer-mill type, driven by 150-hp. 720-r.p.m. 550-volt Allis-Chalmers motors .....Pennsylvania Crusher Co.
Coal weighers, 36 in. wide.....Merrick Scale Mfg. Co.

### Ash-Handling Apparatus

Ash hoppers and gates, tile-lined sectional, cast-iron .....Allen-Sherman-Hoff Co.
Clinker chambers, sluiceways and nozzles .....Allen-Sherman-Hoff Co.
Clinker grinders, double-roll, with cast-iron rolls and removable manganese teeth, driven by 25-hp. 1,200-r.p.m. 2,300 volt G.-E motors .....Allen-Sherman-Hoff Co.
Ash-handling pumps, two 100-g.p.m. manganese-steel vertical centrifugal, direct connected to G.-E. motors.....Morris Machine Works

### Turbine Equipment

Turbine-generator units, two, 55,000-kw. 68,750-kva., 13,200-volt 1,800-r.p.m., for 425-lb., 725-deg. F. steam, four-stage bleeding, with 200-kw. 250-volt direct-connected exciters .....Westinghouse Elec. & Mfg. Co.
Generator air coolers, raw water type, with 18,200 sq.ft. of surface.....General Electric Co.
Condensers, one per turbine, 60,000 sq.ft. each, horizontal divided-waterbox type, two-pass, with 9,750 1 in. x 23 ft. 9 in. Muntz metal tubes.....C. H. Wheeler Mfg. Co.
Automatic vacuum trips, Pigott automatic trippers .....Consolidated Engine Stop Co.
Circulating water pumps, two per condenser, two-stage 1,100-g.p.m. 230-ft. head centrifugals, direct connected to 100-hp. 1,200-r.p.m., 2,300-volt G.-E. motors..C. H. Wheeler Mfg. Co.
Air pumps, two per condenser, radojet type, with combined inter- and aftercondensers .....C. H. Wheeler Mfg. Co.
Travelling screens, three, 46 ft. 6 in. high x 9 ft. wide .....Link-Belt Co.
Motor-generators, one, 200-kw. 250-volt compound wound .....Crocker Wheeler Co.
One 75-kw. 250-volt shunt-wound, one 10-kw. 250-volt shunt-wound and one 5-kw. 250-volt shunt-wound sets .....General Electric Co.
Storage battery, one, 120-cell..Electric Storage Battery Co.
Switchboards, three-section benchboard, control and meter panels .....General Electric Co.

### Feed-Water Heating Equipment

Stage heaters, four for each turbine, vertical-condenser type, with floating waterbox head, ¾-in. Admiralty tubes; Nos. 1, 3 and 4 heaters are four-pass and No. 2 is a two-pass unit .....Elliott Co.
Deäerators, one for each turbine, horizontal cylindrical direct-contact type, with ingot-iron plate and surface vent condenser.....Elliott Co.
Evaporators, two, recirculating film-type of 1,175 sq.ft. surface and 30,000 lb. per hour capacity each .....Elliott Co.
Boiler feed pumps, four 6-in. 5-stage Cameron centrifugal, 650,000 lb. per hr.; one driven by non-condensing turbine and three by 650-hp. 1,800-r.p.m., 2,300-volt G.-E. motor .....Ingersoll-Rand Co.
Surge tanks, two, with 72,000-gal. total capacity ....International Combustion Engineering Corp.
High-pressure drainage control system....Swartwout Co.

### Auxiliary and Station Pumps

High-pressure service pumps, two, 900-g.p.m., 1,800-r.p.m. Cameron centrifugals, direct connected to 150-hp. 2,300-volt G.-E. motors .....Ingersoll-Rand Co.
Low-pressure service pumps, two, 800-g.p.m. 1,800-r.p.m. Cameron centrifugals direct connected to 50-hp. 2,300-volt G.-E. motors .....Ingersoll-Rand Co.
Low surge tank pumps, two, 400 g.p.m., 1,800-r.p.m. Cameron centrifugals direct connected to 30-hp., 550-volt G.-E. motors .....Ingersoll-Rand Co.
Low-pressure heater drain pumps, two, 150-g.p.m. 1,800-r.p.m. Cameron centrifugals, direct connected to 30 hp. 2,300-volt G.-E. motors .....Ingersoll-Rand Co.
Evaporator recirculating pumps, two, 550-g.p.m. 1,200-r.p.m. Cameron centrifugals, direct connected to 5-hp. 550-volt G.-E. motors .....Ingersoll-Rand Co.
Evaporator feed pumps, two, 75-g.p.m. 1,800-r.p.m. Cameron centrifugals, direct connected to 3-hp. 550-volt G.-E. motors..Ingersoll-Rand Co.
Station sump pumps, two, 250-g.p.m., 1,200-r.p.m. centrifugals, direct connected to 7.5-hp. 550-volt G.-E. motors, and one 1,000-g.p.m. 1,200-r.p.m. centrifugal, direct connected to 25-hp. 550-volt G.-E. motor .....Morris Machine Works

### Auxiliary Equipment

Air compressors, two, 370-c.f.m., 100 lb. pressure, Texrope-driven by 75-hp. motors. Ingersoll-Rand Co.
Turbine room crane, one, with 125-ton main and 20-ton auxiliary hoists.....Whiting Corp.
Machine shop crane, one 5-ton .....Shepherd Niles Crane and Hoist Co.
Intake-structure crane, one 20-ton.....Shepherd Niles Crane and Hoist Co.
Piping, general .....W. K. Mitchell Co.
Main steam header .....Keokuk Steel Casting Co.
Pipe covering .....W. Reid Hayden, Inc.
Valves .....Chapman Valve Mfg. Co. and Crane Co.
Non-return stop valves .....Schutte & Koerting Co.
Cast-steel fittings ....Pittsburgh Valve Fdy. & Const. Co.
Cast-iron fittings .....Stockham Pipe & Fittings Co.

# Causes *of and* Remedies *for*

# *Faulty Induction-Motor Operation*

By M. E. Wagner
*New York City*

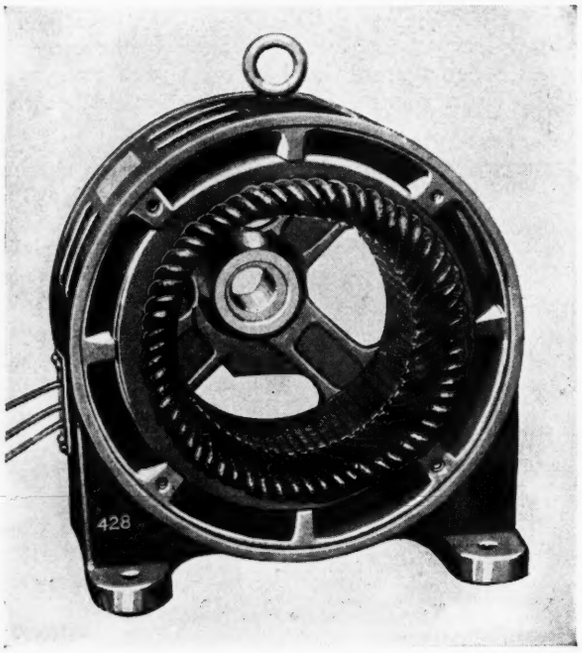



*Fig. 1—Induction-motor stator*

ALTERNATING-CURRENT motors are built in a wide variety of types, and the troubles that may develop in these machines will, to a considerable extent, be influenced by the type of motor. This article will be devoted to polyphase induction types, but many of the suggestions for locating faults are applicable to alternating-current motors in general. The squirrel-cage type motor is of simple construction. It consists of a stator, Fig. 1, with an insulated winding that is connected to the source of power. In the squirrel-cage type the rotor, Fig. 3, has a bar winding, generally uninsulated, and has no connection to the source of power. The wound-rotor type has a stator the same as for the squirrel-cage motor, but on the rotor, Fig. 2, is an insulated winding connected to three slip rings. When starting, these rings are connected to an external resistance, which is gradually cut out of circuit as the rotor comes up to speed.

The faults that may develop in induction motors can be classified as low torque, high torque, low speed, high speed, noise and vibration, heating and failure to start.

Low torque in an induction motor may be caused by low voltage or by conditions in the motor. The torque of an induction motor varies as the square of the applied voltage. This characteristic makes an induction motor sensitive to voltage change. With 90 per cent normal voltage applied to the motor terminals the torque is only 81 per cent of that developed with 100 per cent normal volts. When 110 per cent normal volts is applied to the motor terminals the torque is 121 per cent of that produced by normal voltage.

The foregoing figures show that a variation in the voltage applied to the stator terminals of from 10 per cent below normal to 10 per cent above causes a change in the torque from 81 to 121 per cent. This is equivalent to an increase in torque of almost 50 per cent above that obtained at the lower voltage. From this it is evident that a fluctuating voltage on an alternating-current circuit may be the cause of serious trouble in the operation of induction motors. If motors are giving trouble, such as low torque, low speed or heating, one of the first things to check is the line voltage. If this is found to be low, effort should be taken to correct the condition.

When large squirrel-cage motors are started at the end of a long line, the heavy starting current may cause sufficient voltage drop to reduce the motors' torques below a value sufficient for starting, particularly if the motors must start under considerable load. Under such conditions a wound-rotor type of motor would be more satisfactory, as it takes only 33 to 50 per cent of the current that the squirrel-cage type does to develop the same starting torque.

The speed of a given induction motor is determined largely by the frequency of the power supply. If the frequency is low the motor's speed will be low. When an induction motor runs at a speed considerably below that given on its nameplate, if there is any doubt about the frequency of the circuit, this factor should be checked. On most of the large power systems, the frequency is maintained close to normal. This, however, is not true on some of the smaller systems.

Even if effort is made to

Induction motors are quite simple machines but they are capable at times of presenting some baffling cases of trouble. In this article, faults due to the line voltage and frequency, starting equipment and the mechanical features of the motor are discussed. A future article will deal with faults in induction-motor windings.

hold the frequency near normal, while using the ordinary indicating-type frequency meter, the instrument may be in error. This can be checked easily by counting the number of poles in a generator and taking its speed. The frequency in cycles per second is then equal to the product of the number of poles and the speed in revolutions per minute divided by 120. For example, if the generator's speed was found to be 580 r.p.m. and the number of poles 12, the frequency of the system would be $(580 \times 12) \div 120 = 58$ cycles per second. If, under these conditions, the frequency meter indicated 60 cycles, it would be evident that the meter was indicating two cycles too high.

The frequency of the circuit can also be checked by the speed of a synchronous motor. If the indicated speed of a synchronous motor does not check with that given on its nameplate, it shows that the frequency is in error. For example, if the nameplate on a ten-pole synchronous motor intended to be operated on a 60-cycle system gave the speed as 720 r.p.m., but the indicated speed was only 690, it would show that the frequency of the circuit was low. The frequency corresponding to the motor's speed is equal to the number of poles in the motor times the speed divided by 120. In this case the motor has 10 poles and the speed is 690 r.p.m.; then the frequency corresponding to the motor's speed equals $(10 \times 690) \div 120 = 57.5$ cycles, or the frequency is $60 - 57.5 = 2.5$ cycles per second slow.

Both the voltage and frequency of the line should be the same as that for which the motor is designed, to obtain the best operating results. Motors are generally designed to stand a 10 per cent variation in voltage, provided the frequency is held at normal value. If the frequency varies, it should change in the same direction as the voltage, otherwise it will tend to add to the bad effects of the voltage change. If the voltage decreased 10 per cent and at the same time the frequency decreased 10 per cent, the motor would, internally, be operating normally, but its output would be decreased about 10 per cent. On the other hand, if the frequency were to decrease 5 per cent, with a 5 per cent increase in voltage, it would approximately be equivalent to a 10 per cent increase in voltage above normal at normal frequency.

A change in voltage or frequency produces different effects, depending upon the direction of the change and the combination of the two. If the voltage is low, the iron losses are decreased and the copper losses increased for a given horsepower output. Conversely, if the voltage is increased, the iron losses are increased and the copper losses decreased. If the variation in voltage is sufficient, the concentration of losses in the iron or copper may cause a burn-out of the windings.

A reduction in frequency would cause an increase in the magnetizing current and would, therefore, for a given horsepower output, tend to decrease the power factor of the motor. The speed will be decreased in direct proportion to the frequency, and this will decrease the natural ventilation of the motor and increase its temperature. If the frequency is decreased, the horsepower rating of the motor should be decreased. Should the frequency be made very low, such as would result from connecting a 60-cycle motor to a 25-cycle circuit, the magnetizing current may exceed the full-load current of the motor. Under such conditions the motor would overheat at no load.

A motor operating at reduced voltage and normal frequency will have a better power factor than when oper-

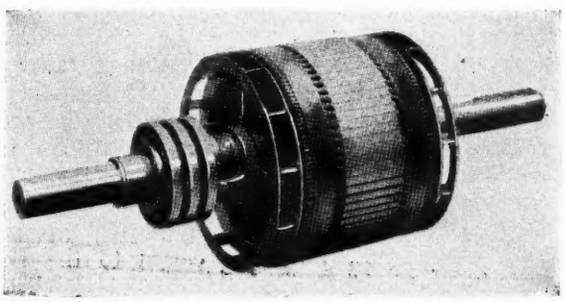


*Fig. 2—Wound rotor for an induction*

This type of rotor has a three-phase insulated winding connected to three slip rings that are connected to a resistance at starting.

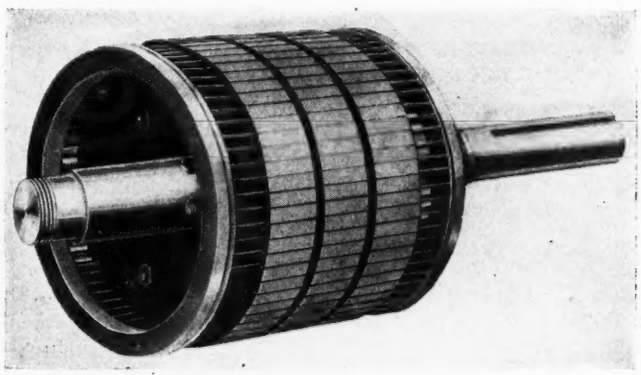


*Fig. 3—Squirrel-cage type rotor*

The bars in this rotor are driven into the slots without insulation and the end rings are cast on.

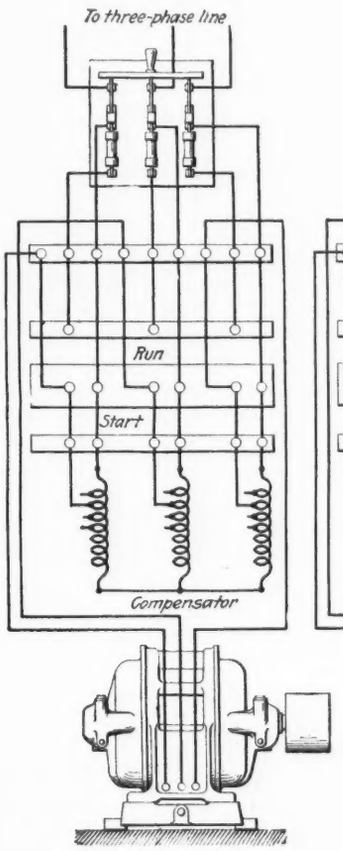



*Fig. 4—Diagram of starting compensator closed to the starting position*

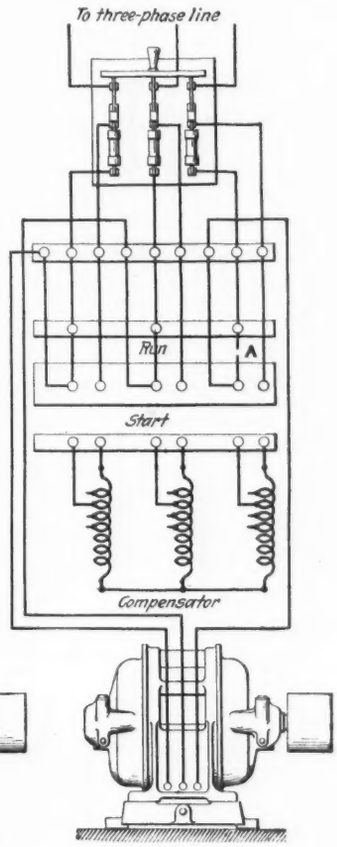



*Fig. 5—Diagram of starting compensator closed to the running position*

ating at normal frequency, assuming the same horsepower output in both cases. On account of increased copper losses, the motor will probably overheat if it is operated at its rated horsepower.

An increase in frequency with normal voltage will cause a decrease in the magnetizing current and in the field strength, and the power factor for a given output will tend to improve. The speed of the motor will be increased, and this will improve the natural ventilation of the motor. Within a reasonable limit of frequency change, the heating should be less for a given horsepower output.

From the foregoing it is evident that a change in voltage or frequency or both may have a marked effect on the operation of induction motors. If trouble is being experienced with improper speed, torque or heating, the voltage and frequency of the power supply should be checked.

When checking the voltage, readings should be taken on all phases. If the voltage is materially out of balance, it will cause the motors to overheat. An induction motor connected to a circuit with the voltage out of balance will act to balance the voltage on the system. If the voltage is considerably out of balance it is possible for one phase in the motor to act as a generator and instead of taking power from the line to deliver power. Such conditions overload one phase in the winding and cause overheating during operation and low torque at starting.

Poor connections between the bars and end rings on the rotors of squirrel-cage motors is another cause of overheating, low speed and low torque. This cause was more prevalent in the earlier types of motors than in modern machines, which have cast-on or welded end rings. In the earlier types of motors the connections between the end rings and bars were made by bolts or by other methods and could work loose. If trouble is experienced with loose connections in the rotor the best way to eliminate it is to weld the bars to the end rings. Loose connections between the bars and end rings will throw the motor out of balance electrically and cause noisy operation, vibration and overheating. Worn bearings may have similar effects and in addition cause low torque.

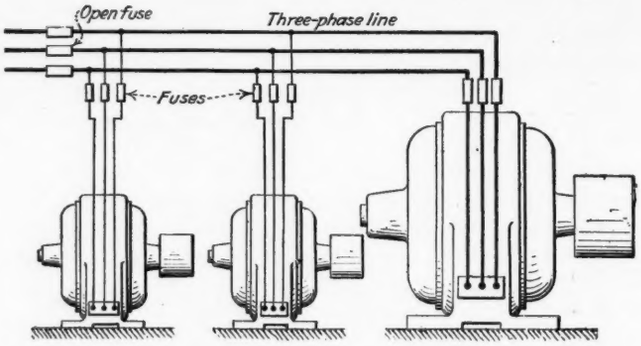



*Fig. 8—Diagram of three induction motors on the same feeder*

Open-phase operation is a common cause of overheating, and may even cause noise. A polyphase motor will not start on single phase, but will run on single-phase power after being brought up to speed. When a two- or three-phase motor is protected by fuses there is always danger of one of them failing when the motor is running, leaving the motor operating single phase. An open circuit in the wiring will also cause single-phase operation.

When squirrel-cage motors are started by a double-throw switch with the fuses out of circuit, the motor may be started on polyphase current and operated on single-phase if one of the fuses is open.

Compensator-type starters permit starting on polyphase reduced voltage and operating on single-phase full voltage. For example, in Fig. 4 all the circuits to the motor are complete through the low-voltage connections. This allows starting the motor in a normal manner. When the compensator switch is closed to the full-voltage position, Fig. 5, one of the contacts might be open as at *A*. Such a fault would allow single-phase operation of the motor.

To test for such a fault, the motor leads may be disconnected at the motor and a test lamp connected in circuit, as in Fig. 6. Then close the line switch and throw the compensator first to the starting and then to the running position. The lamp should light with the compensator in either position. Tests should be made on all phases.

When the voltage is too high to allow using a test lamp, as in Fig. 6, the line switch can be left open and short circuited, Fig. 7, then connect a test lamp to one of the phases at the motor, as in the figure. After this connection is made, the compensator is tested by closing its switch first to the starting and then to the running position. The lamp should light with the compensator switch closed to either position. After completing the test on one phase the others should be tested. Failure of the lamp to light with the compensator switch closed indicates an opening in this position of the switch. With some of the earlier type of compensators using a butt-

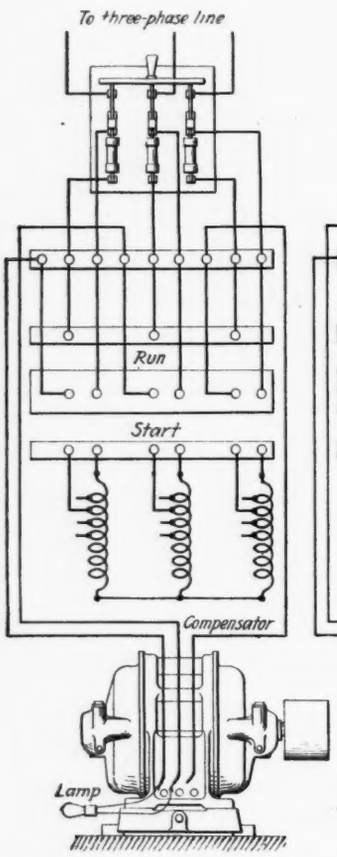



*Fig. 6—Testing a compensator with line voltage*

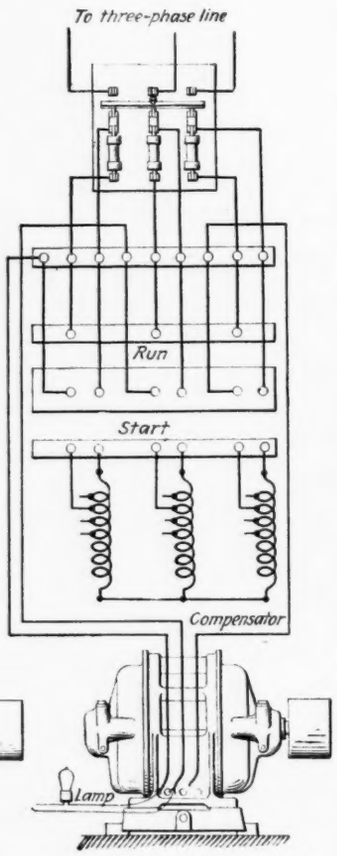



*Fig. 7—Checking a compensator with a testing circuit*

type contact switch, it was not uncommon for the contacts to develop burnt spots, causing open circuits.

A polyphase motor operating single phase becomes a phase converter and will supply polyphase power on the load side of the open circuit. Where a number of motors are operated off the same feeder, as in Fig. 8, it is possible for one line fuse to fail and still start motors on the feeder. In one case in mind a large motor and a number of small ones operated on the same feeder. One of the fuses opened in the feeder, but it was not detected for some time. The large motor was in continuous service, only the small ones being shut down.

The large motor, being in service, maintained the open phase alive to the small motors, so that they could be started as polyphase machines. As the large motor was not heavily loaded, it was capable of driving its load and acting as a phase converter for the other motors without overheating. When the large motor was shut down it would not start again, but acted as if one phase were open. In this case the small motors did not have sufficient capacity to act as phase converters for the large motor. A test at the large motor fuses showed, apparently, that the line was alive. When looking for the trouble the small motors were shut down. Then it was found that they could not be started again. A test of the circuit then showed one phase was open. Replacing the open fuse resulted in normal conditions.

To protect motors against open-phase and reverse-phase operation, reverse-phase relays are frequently used. Properly adjusted thermal overload relays also serve as protection against open-phase operation. In some cases where fuses are used a lamp is connected in parallel with each fuse. When a fuse opens, the lamp will light and call attention to the fuse that is open. When lamps are used to check fuses it is advisable to test the lamps periodically to make sure that they have not failed. Otherwise a defective lamp may defeat the purpose for which it was intended.

# Heating in Automatic Substations

By R. P. Brockner

BUILDING heating in automatic substations presents a problem entirely different from the heating of any other type of building.

Since for a majority of the time the building is unoccupied, the problem is not one of providing a comfortable working atmosphere. It is necessary, however, to provide heat, in order to prevent condensation of moisture on the metal parts of electrical equipment, as well as on insulators and other parts. A failure to accomplish this may result in a costly flashover or short circuits.

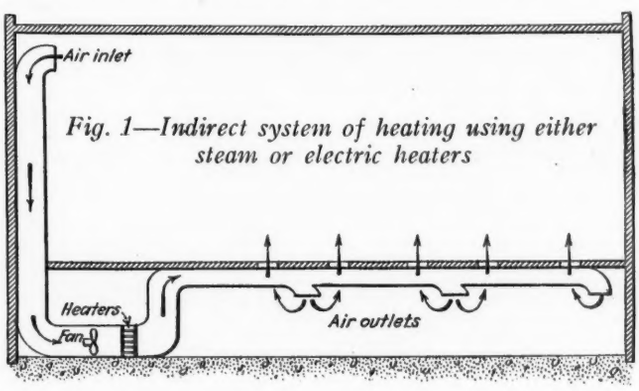



*Fig. 1—Indirect system of heating using either steam or electric heaters*

It has been found that if the building is kept at a temperature of about 50 deg. no condensation will occur. The maintenance of this low temperature naturally requires much less heat than is necessary in any ordinary building of the same size.

One method of accomplishing this is to install a steam heating system with its boiler and direct radiation. However, a somewhat more effective and less expensive installation can be made as shown in Fig. 1. In this arrangement a boiler supplies steam to a set of vento heaters, thus materially reducing the amount of necessary piping. A fan draws air from an inlet about twenty feet above the operating floor, blows it over the vento heaters and delivers it to the basement. The air then rises through gratings in the operating floor to the operating room, thus heating the building. This method of heating has been found to effectively prevent the formation of moisture, and the fan lends itself to thermostatic control.

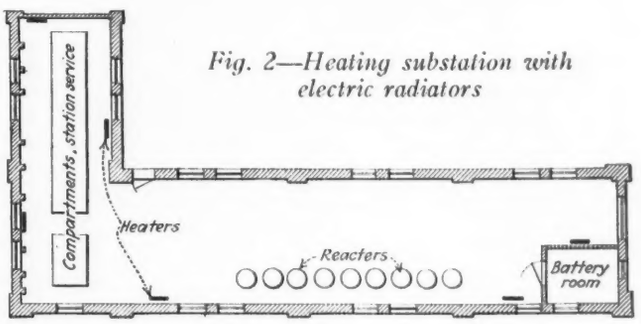



*Fig. 2—Heating substation with electric radiators*

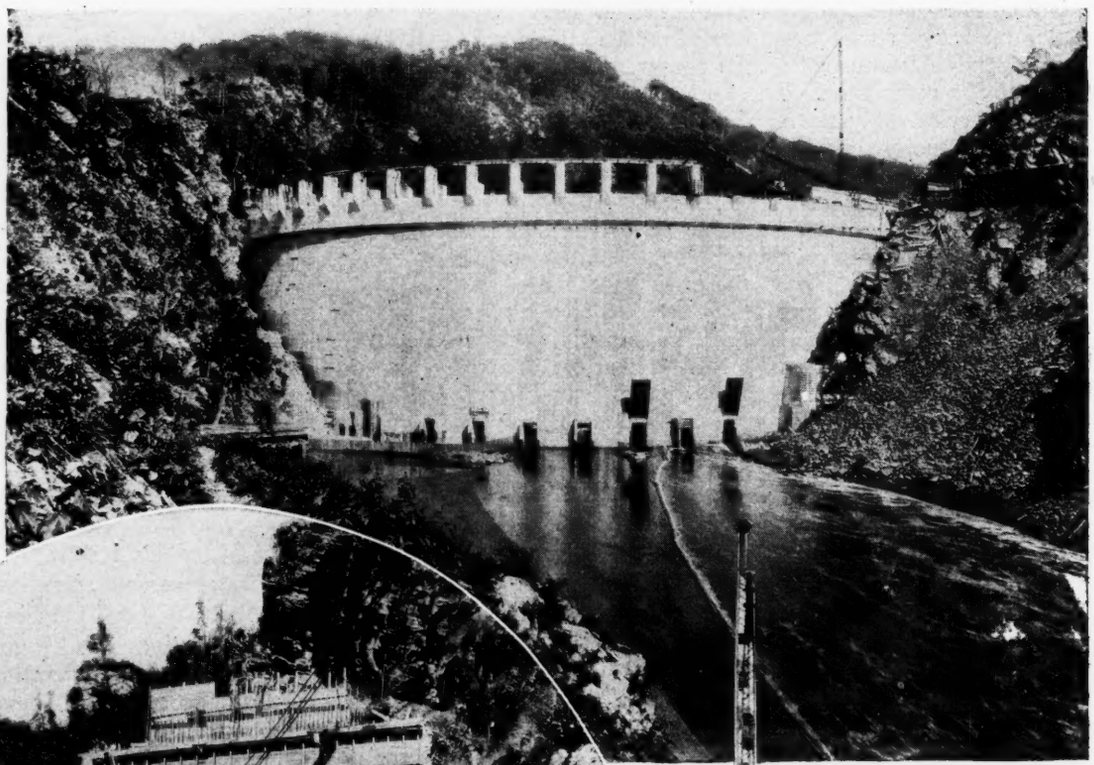
There is, however, a basic objection to the system—the steam boiler requires the presence of an attendant, which necessarily defeats the purpose of an automatic substation, the electrical equipment in which is designed to operate without the attention of an operator.

One method of eliminating the necessity of providing a man to operate the boiler is to accomplish the heating with electric energy. Fig. 2 shows the plan layout of a substation in which electric radiators of the four-coil type were installed on the walls of the building about eighteen inches above the floor. Three 50-kw. heaters were installed in the basement and six 7.5-kw. heaters were installed in the first floor. The total energy demand of this installation is 60 kw.-hr. In this system natural circulation is depended upon entirely to convey heat to all parts of the building.

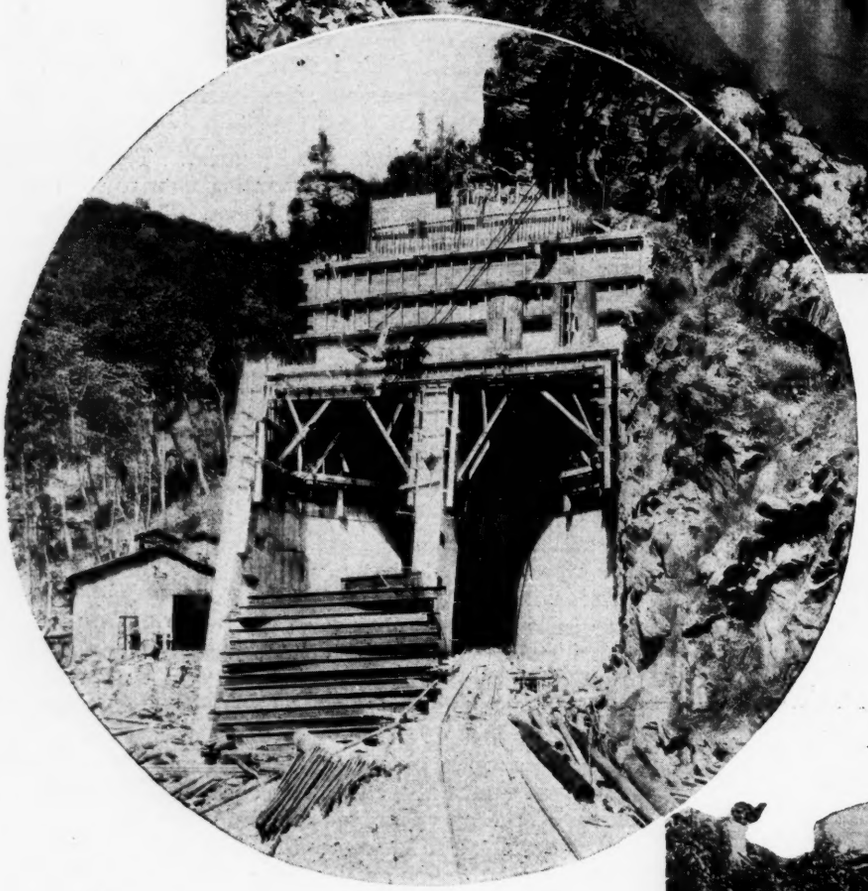
The electrical heating of the building may be improved by providing fans in the basement that draw air from the ceiling of the operating room and force it through the electric heaters, also located in the basement. The heated air then rises through gratings in the operating floor and completely heats the building. This system is the same as shown in Fig. 1 except that electric heating elements are substituted for the vento heaters.

The use of electrical energy for heating this type of building has many obvious advantages. It entirely eliminates the necessity of an attendant; coal dust and ashes do not dirty the basement; it is particularly adapted to thermostatic control, thus being entirely automatic in its operation; and the cost of electrical energy does not greatly exceed the cost of heating with coal, if the wages of a janitor are considered.

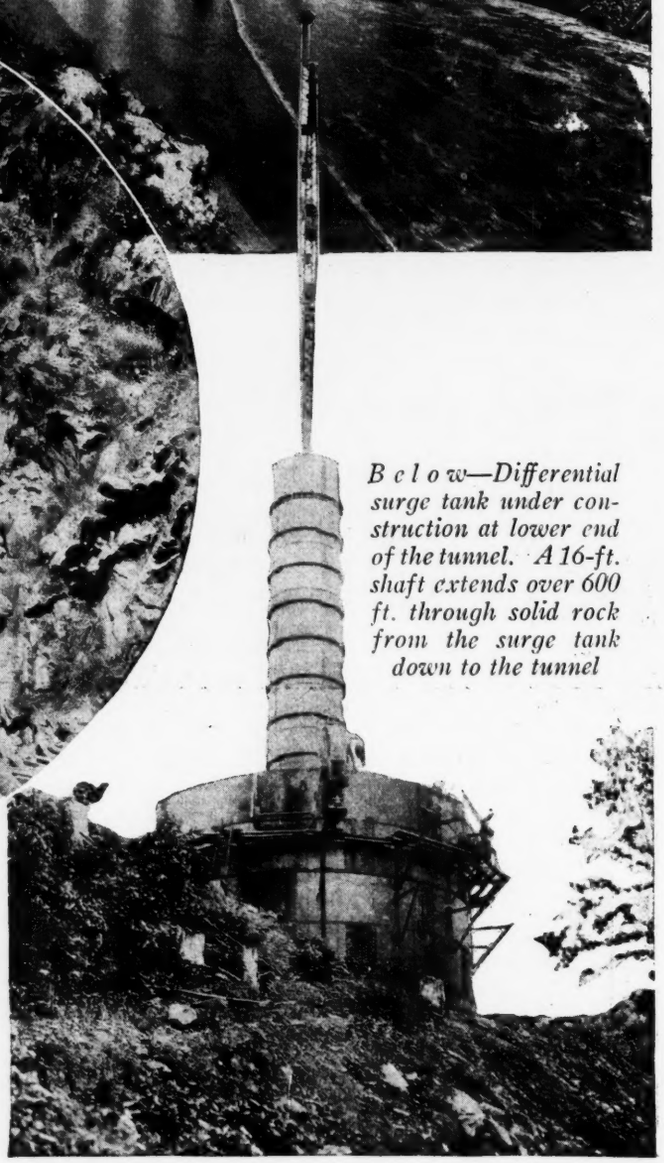
# Highest-Head Hydro-Electric Plant in the East



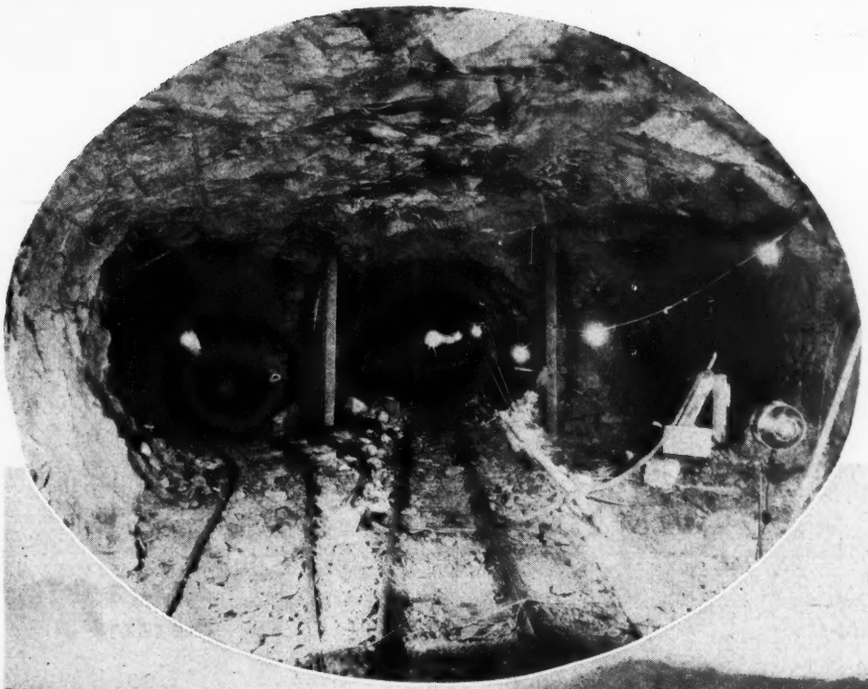
*Upstream face of the dam on the Waterville development of the Carolina Power and Light Company, on the Pigeon River, about 35 miles northwest of Asheville, N. C.*



*Above—Entrance to the concrete-lined pressure tunnel, which is more than six miles in length and 14 ft. in diameter. The difference in elevation between the upper and lower ends of the tunnel is 734 ft. The static head at the plant is 860 ft. and the normal operating head 775 feet*



*Below—Differential surge tank under construction at lower end of the tunnel. A 16-ft. shaft extends over 600 ft. through solid rock from the surge tank down to the tunnel*



*Left—At the lower end of the tunnel there is a transition for a 14-ft. circle to three parallel tunnels each carrying a steel penstock leading to the units in the power house*

*Above—The power house will have three units with an aggregate capacity of 100,000 kw. Single-runner vertical-shaft reaction turbines are being installed and are the highest-head units east of the Rocky Mountains. Work on this project was started in 1927, and it is expected to be ready for service early in 1930*

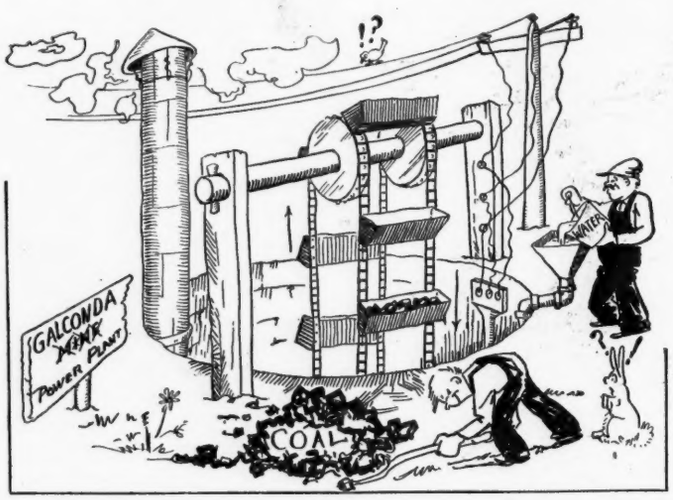
*Right — Downstream face of concrete spillway dam, which is a single variable radius arch 180 ft. high and 900 ft. long. The flow over the dam will be controlled by 14 tainter gates 24 ft. long*

# Mr. BUNCOMBE Tells How—

# "Supernatural Power, Inc."

**Runs on a 35-Inch Vacuum**

**Eliminates Feed Pumps**




**Gets Extra Power From Coal Conveyor**

AUGUST is always a dull season with us, and at 3 o'clock one afternoon I was seated at my desk doing nothing more important than wishing for something to turn up. I was therefore in a tolerant mood when the office boy handed me a card heavily engraved "W.E. Buncombe, representing Supernatural Power, Inc." I asked that he be sent in, and, as he strode in the door, I noted his hypnotic eyes, his bulging brief case, and the slide rule that protruded from an inside pocket.

After the preliminary greetings, he delivered himself of the following:

"As you will see from my card, I represent Supernatural Power, Inc. I expect to sell you stock in this organization, but before discussing the financial side of the matter I wish you to convince yourself of the technical merits of our electric power-generating process which enables us to produce electric energy at a substantially lower cost than any existing plant regardless of size or price of fuel. To remove the slightest suspicion of personal magnetism or high-pressure salesmanship, I suggest that you read this description of our proposed Galconda Power Plant."

It was a hot afternoon and I meekly accepted the printed matter he handed me. There were gold edges on the booklet, and the cover design was a large dollar sign. It read as follows:

"SUPERNATURAL POWER, INC.

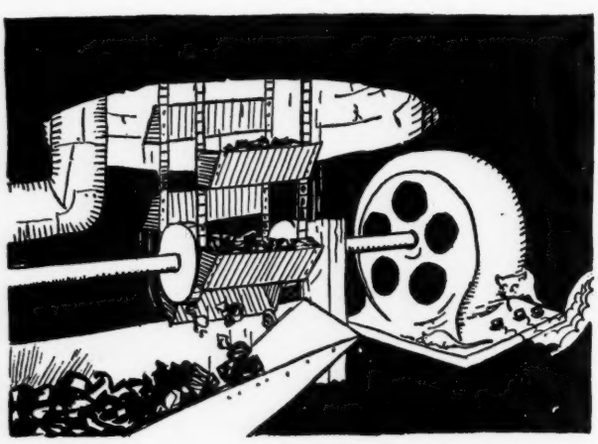
"The Galconda Power Station will be of 5,000-kw. initial capacity and will be equipped with turbine-generators of the most modern type, coal-fired boilers operating at the highest commercially practicable pressure, and auxiliaries of the latest design, all in line with usual engineering practice. The unusual feature is that the plant will be located at the bottom of the abandoned shaft of the Galconda Consolidated mine. Here, 6,000 ft. below the surface of the earth, in a gigantic chamber from which millions of dollars worth of ore have been removed, will be installed the complete generating station.

"The first point of superiority brought about by this novel location is the high vacuum obtained. As is well known, a condensing plant at sea level is fortunate if a 29.6-in. vacuum is secured. A plant at 6,000 ft. elevation can get not more than 24 in. In our plant, 6,000 ft. below sea level, a vacuum on the order of 35 in will be constantly maintained, enabling us to secure unparalleled turbine economy.

***Locating this power plant 6,000 ft. underground effects tremendous savings, says Mr. Buncombe. But would it?***

*As told to*

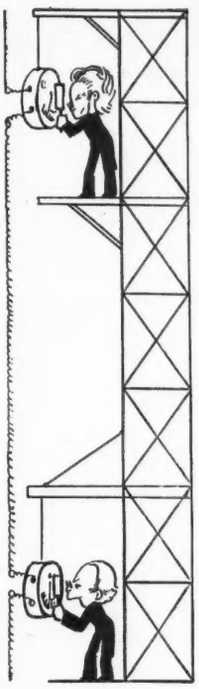
ELMER S. SMAIL



The second feature is the boiler feed pump. In high-pressure plants a large amount of power is required to pump the feed water into the boilers against the operating pressure. Roughly, one-half of 1 per cent of the usual power station cost is represented by boiler feed pumps and their drives. In this plant we absolutely eliminate boiler feed pumps. It is a matter of elementary engineering that a 2.3-foot head of water gives a pressure of 1 lb. per sq.in. In our plant the feed water descends 6,000 ft., giving us the enormous pressure of 2,600 lb. per sq.in., far more than enough to force the water into the boilers. Frankly, there will be a slight offset against the saving of the cost of feed pumps, because reducing valves will have to be installed. The power saving, however, is quite obvious and aids materially in securing low cost of production.

"Item No. 3 is draft-producing apparatus. Everyone is familiar with the towering stacks which are such prominent features of the usual electrical plant. These stacks cost a lot of money, in fact the cost becomes almost prohibitive for heights greater than 300 ft., and even with this height the stack must be assisted by fans if economizers or preheaters are to be installed. In our plant we have not a 300-ft. stack, not a 600-ft. stack, but a 6,000-ft. stack, built of light material and supported on the side of the existing mine shaft. Imagine the draft produced by a 6,000-ft. chimney! Not only will induced-draft fans be eliminated, but dampers will replace the forced-draft fans customarily used to supply air to the stokers. The savings in first cost and operation will be apparent to any intelligent engineer. A further saving, not quite so obvious, is in painting the stack. This is an expensive process for the usual central station, as special men are required, the average painter being unwilling to work at such dizzy heights. In our plant the stack goes up close to the present hoisting cage, and it is proposed to connect a system of paint sprayers to this cage and the entire stack can be coated with preservative paint in one trip at little more than the cost of material.

"Point 4 is coal-handling. In the conventional power house coal is unloaded, picked up by buckets of various types, and transported considerable distances into overhead bunkers, from which it falls into the stoker hoppers. The first cost of this equipment frequently amounts to three per cent of the entire plant cost, and the power required to operate all this machinery is a big item. In our plant this debit is actually changed to a credit in the following simple manner, fully covered by patents applied for in all countries of the world.



*Electrical energy suffers no loss due to gravity*

"Coal at the surface is dumped directly from the railroad cars into buckets carried on an endless conveyor belt. The weight of the loaded buckets descending 6,000 ft. causes the sprocket drums at top and bottom to turn at a high rate of speed. The drum shaft at the bottom is attached to a generator, which produces electrical energy without burning a single pound of coal. It is estimated that the furnaces for the main units will consume 50 tons, or 100,000 lb., of coal per hour, all of which descends 6,000 ft., giving a useful output (with 85 per cent efficient mechanism) of 510,000,000 foot-pounds per hour absolutely free. A further feature is that the poorer the quality of coal used, the more weight required, and the greater the power recovered during its descent. An ignorant person might suspect that this power would be lost in raising the electrical output to the surface, but it has been proved that electrical energy travels on vertical wires without suffering any loss due to gravity. Ash disposal will be very easy for many years to come, as it will be dropped into some of the smaller and deeper mine workings.

"Several minor points should be covered briefly, such as real estate, taxes, and building costs. The cost of real estate will be almost nothing, as, now that the ore has been removed, the mining company will practically give it away if they can be assured that it will not pass into hostile hands. Taxes will be trivial, as the only equipment visible to the eyes of the assessor will be the coal-dumping machinery at the surface.

"Another item of which our engineers expect much but which we will not attempt to evaluate to prospective security purchasers, is the heat in the air. It is known that as we descend into the earth the temperature increases. Some authorities say 1 deg. F. for every 100 ft. If this proves accurate, our combustion air will be heated enough to materially reduce the size of the air heaters.

As I finished reading the prospectus I looked up to find Mr. Buncombe uncapping his fountain pen.

"Are there any questions you wish to ask before subscribing?" he inquired.

I had one question to ask. I think it was very clever of me. I inquired what they would do with the ashes after they had filled up the available empty galleries.

"That," he replied, "is a very shrewd question, and I'll tell you, although we have not yet patented the process. When that time arrives it is inevitable that our furnace linings will be somewhat depreciated. We propose to make a refractory cement from the ashes and use this to repair the damaged furnace walls."

I had nothing more to ask. I obediently signed on the dotted line. Since that time I have been vexed with vague doubts of my wisdom in buying this stock; but I can't see where there is anything wrong. The practice is unusual, but the theory sounds all right—or doesn't it?

*6,000-ft. stack is painted with ease*

# Oil Engine Research

## at the UNIVERSITY of TORONTO

By Campbell Bradshaw

*Convinced that the two-stroke-cycle oil engine is destined to become far more important commercially that it now is, extensive research on internal combustion was begun several years ago, and is still being carried on, by Prof. E. A. Allcut, in the Department of Mechanical Engineering at the University of Toronto.*

WHEN Prof. Allcut began his research work in oil engines he found it impossible to get a small two-stroke-cycle Diesel engine suitable for his purpose. As a result an Allen engine of the hot-bulb type with crankcase compression was purchased in England. Such an engine has the disadvantages that the heat for ignition is partly supplied by the hot bulb and that the scavenging efficiency is low on account of the small quantity of compressed air available, the varying pressures during scavenging, and the loss of air through the ports during the scavenging period. In addition, the formation of a vortex of exhaust gases, which occupied a part of the cylinder during the scavenging operation, as shown in Fig. 1, and mixing with the fresh charge, diluted the air and raised its temperature, also reducing volumetric efficiency.

A review of the literature available on the subject failed to bring to light the information required. Therefore tests were first made at various loads, and a special indicator connected to the passage joining the crankcase to the inlet ports.

A thermometer was also inserted at this point to indicate the mean temperature of the scavenging air, as it was felt that, owing to the small weight of air compressed and the heavy mass of metal, the compression would be nearly isothermal and little cyclical variation of temperature would result.

Indicator diagrams and records of combustion pressures were taken at regular intervals and samples of exhaust gas were withdrawn into a gas holder having a capacity of 2 cu.ft., to be subsequently analyzed in a Burrell gas-analysis apparatus. The exhaust temperatures were taken with a chromel-copel thermocouple, and the cooling-water losses were found by weighing the water, the outlet temperature in all cases being kept, as nearly as possible, at 135 deg. F. The no-load test was made by removing the rope brake used during the other tests. The fuel used was a light fuel oil having a specific gravity of 0.849 at 74.8 deg. F. Its calorific value, obtained both with a Parr calorimeter and a special calorimeter devised for the purpose, was 19,850 B.t.u. per lb., higher value, and 18,715 B.t.u. per lb., lower value. It contained 84.45 per cent of carbon and 13.01 per cent of hydrogen, and its flash and flame points were, respectively, 186 and 202 deg. F. The results of the tests are given in Figs. 2, 3 and 4.

Fairly uniform combustion pressures were obtained at the heavier loads, but during the no-load test missed explosions were frequent. In this case the pencil was kept on the paper until a diagram was obtained, and the resulting mean effective pressure was then multiplied by the ratio of firing to total cycles to obtain the true mean. The result thus obtained checked fairly closely with the difference between i.h.p. and b.h.p. in the other tests. The value of $n$ in the equation $PV^n =$ constant for the working strokes varied from 1.04 to 1.13, a low figure, suggesting that combustion continued until late in the expansion stroke. This was verified later by plotting characteristic diagrams on a temperature-entropy basis, from which it was evident that combustion was not complete in most cases until the piston had covered 60 per cent of the downward stroke. This result suggests late injection, but prior to these tests the injection had been advanced until the combustion at heavy loads was practically at constant volume.

In calculating exhaust losses, allowance was made for the heat lost in kinetic energy, due to the exhaust gas expanding abiabatically through the ports after release.

As the percentages of $CO_2$ in the exhaust gas were considerably lower than expected, calculations were made from the crankcase diagrams of the amount of $CO_2$ that should be present. It was then considered that the curve of $CO_2$ plotted against crank angles was probably similar to the line *AB* in Fig. 5. But the actual exhaust period was bounded by the period *CD*, so that the analysis of the mean sample was the mean height of the area *AKBFE*, while the true analysis of the gases leaving the cylinder was the weighted mean of the area *CKDGH*. Between the points *C* and *D* the velocity

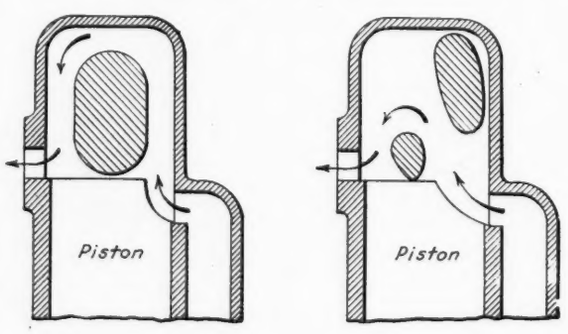



*Fig. 1—Diagrammatical outline of burnt gas vortex formation*

of the exhaust gas starts from zero, rises to a maximum, fluctuates and then diminishes again to zero, so that each of the analyses between *C* and *D* must be multiplied by a velocity factor to obtain the true mean analysis.

Indicator diagrams are shown in Fig. 6, the various expansion curves being for different loads. There is no variation in the compression curve, but the maximum pressures were somewhat difficult to obtain accurately. Starting with a balancing pressure on the diaphragm well above the maximum explosion pressure and gradually lowering it, an occasional click was heard on the telephone, corresponding to the highest pressures reached in occasional cycles. As the pressure was lowered the number of clicks increased until contact was made at every revolution. The mean value lay somewhere between these two limits, but not necessarily midway between them, so that considerable judgment and experience were required to obtain the true mean pressure. This difficulty was increased with decreasing inlet ports open at 137 deg. the flow of air into the cylinder is not sufficient to counteract the rapid fall of pressure until the piston begins to slow down at a crank angle of about 150 deg. The air pressure in the crankcase then begins to fall. There is, however, a period of about 10 deg. near the end of the stroke where the pressure of gas on the cylinder is equal to, and sometimes slightly exceeds, the air pressure, and it is probable that during this period very little air enters the cylinder, and the time of effective scavenging is thus reduced.

In addition to the individual analyses, average samples of gas over the whole cycle were collected by holding the sampling valve open by hand while the engine was running.

During the time when the exhaust ports are closed, from the 240 to 100 deg. angle, there is no gas leaving the cylinder, but merely an oscillation in the exhaust pipe and a probable dilution with air, so that the true composition of the exhaust gas is given, approximately, by

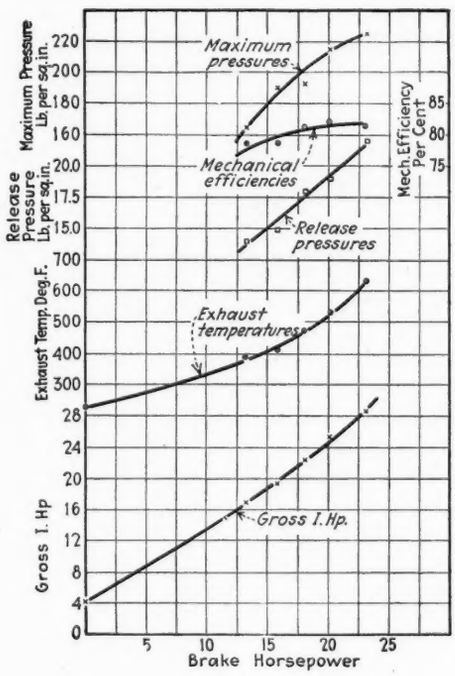



*Fig. 2—Efficiencies, exhaust temperatures and engine loads*

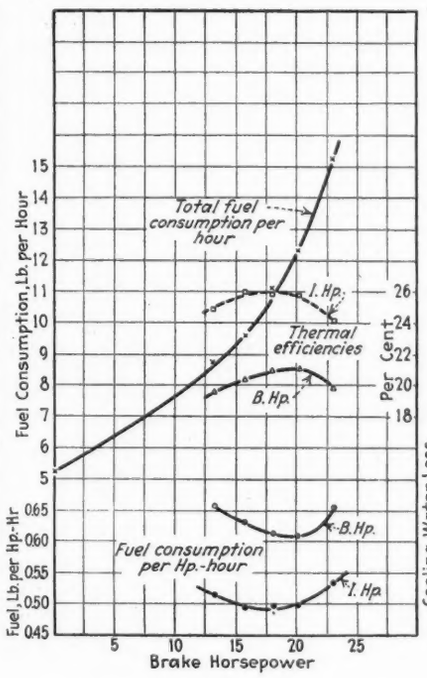



*Fig. 3—Total fuel consumption and indicated load*

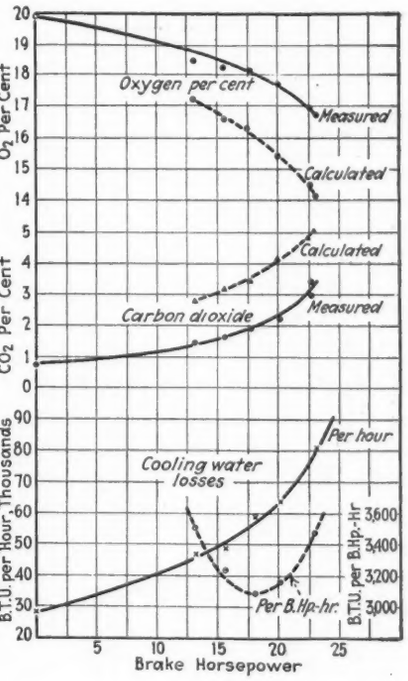



*Fig. 4—Exhaust gas analyses at various loads*

loads, but decreased as the pressures fell along the expansion curve, disappearing at about half stroke.

The comparison between the diagrams obtained from the two indicators is given in Table I, and it is evident from this that in spite of the high speed, 370 r.p.m., and the heavy spring, 320 lb. per in., necessary to dampen out oscillations, the Crosby indicator gave results close to those obtained from the diaphragm indicator, which was unaffected by inertia. The areas were obtained by passing the planimeter five times round each diagram and dividing the result by 5.

The light-spring diagrams for the cylinder and exhaust pipe when laid out on a crank angle basis show that the fluctuations of pressure synchronize almost exactly, falling to a minimum at 150 deg. crank angle, rising above atmospheric pressure to a maximum of 1.5 to 2 lb. per sq.in. at about 175 deg., falling below atmosphere again and finally reaching atmospheric pressure at 240 deg., at which point compression begins. Although the the mean height of the curve between 100 and 240 deg. of crank angle. The observations taken, however, enabled the fluctuations of velocity during the period to be calculated, and therefore the mean analysis when corrected gives a figure close to the true composition of the exhaust gas, as shown in Table II.

The extent of the error when samples are taken in the usual way is about 30 to 40 per cent, the velocity correction being of the order of 3 to 8 per cent. The

TABLE I—COMPARATIVE INDICATOR READINGS

| | Test No. 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Indicated horsepower: | | | | | |
| Diaphragm indicator | 21.5 | 23.2 | 25.7 | 28.7 | 31.8 |
| Crosby indicator | 21.2 | 23.4 | 26.9 | 28.8 | 31.7 |
| Maximum pressure: | | | | | |
| Diaphragm indicator, lb. per sq.in. | 166 | 166 | 187 | 191 | 201 |
| Crosby indicator, lb. per sq.in. | 175 | 178 | 196 | 203 | 203 |
| Value of *n*: | | | | | |
| Diaphragm indicator | 1.19 | 1.19 | 1.25 | 1.19 | 1.16 |
| Crosby indicator | 1.26 | 1.26 | 1.25 | 1.23 | 1.23 |
| Point in stroke at which maximum pressure occurs, inches: | | | | | |
| Diaphragm indicator | .24 | .40 | .24 | .40 | .24 |
| Crosby indicator | About 0.38 in. in all tests. | | | | |

error involved in multi-cylinder engines will evidently be of less extent, depending on the arrangement of the cranks, but the velocity error is always present.

It follows, Prof. Allcut points out, that combustion calculations made from tests on single-cylinder two-stroke-cycle engines and based on exhaust-gas analyses are seriously in error, particularly when it is remembered that the exhaust temperature curve is probably similar in form, and therefore it is susceptible to an error of a similar nature but of lesser extent. The form of this curve is now being investigated at the University of Toronto, with specially sensitive thermometers actuating an oscillograph.

TABLE II—EXHAUST GAS COMPOSITION
($CO_2$ per cent by volume)

| | Test No. 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Analysis of mean samples, per cent | 1.55 | 1.85 | 2.11 | 2.35 | 2.68 |
| Mean analysis from total area of curve (0-360°), per cent | 1.75 | 1.93 | 2.09 | 2.42 | 2.72 |
| Mean analysis from area of curve between 100 and 240 deg., per cent | 2.50 | 2.66 | 2.87 | 3.32 | 4.04 |
| Mean analysis corrected for velocity changes, per cent | 2.58 | 2.77 | 2.98 | 3.55 | 4.37 |

The efficiency of scavenging and the determination of the quantity of air remaining in the cylinder of a two-stroke-cycle engine are difficult to obtain, but these factors are important, as the amount of fuel which can be consumed, and therefore the mean effective pressure obtainable, depends on the amount of air available.

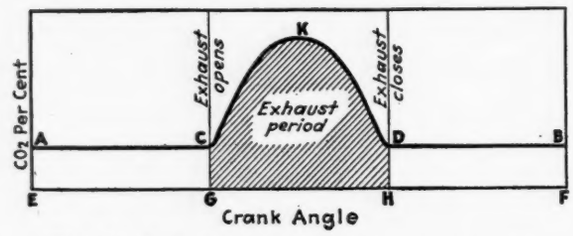



*Fig. 5—Calculated $CO_2$ against crank angle*

Assuming that the analysis which gave the maximum percentage of $CO_2$ in each test represented nearly the composition of the expanding charge, the weight of charge was calculated and the results are given in Table III. They show that with proper admixture of air and fuel a considerably greater quantity of the latter could be burned and the power materially increased.

These calculations also enabled the temperature of the cycle to be determined approximately, with the aid of a special internal energy-entropy diagram drawn for the purpose. In the first tests, the compression temperature ranged from 710 to 780 deg. F., the maximum cylinder temperature from 1,350 to 1,725 deg. F. and the release temperature from 960 to 1,375 deg. F. From the entropy diagrams the maximum temperature is found to occur when the piston has traversed 8 per cent of the power stroke, and this fact, together with the considerable amount of afterburning that exists and the weakness of the charge, indicated by Table III, accounts for the comparatively low combustion temperatures obtained.

TABLE III—AIR IN ENGINE CYLINDER

| | Test No. 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Weight of air in cylinder during combustion period, lb | .0176 | .0196 | .0186 | .0192 | .0176 |
| Weight of air delivered from crankcase per cycle, lb | .0275 | .0272 | .0273 | .0278 | .0273 |
| Percentage of stroke volume occupied by scavenging air at crankcase temperature | 57.4 | 63.3 | 60.3 | 60.9 | 57.8 |
| Weight of air supplied for combustion per lb. of oil fuel, lb | 46.3 | 44.7 | 39.8 | 34.6 | 28.6 |
| Excess air in cylinder beyond that required for complete combustion, per cent | 224 | 212 | 178 | 142 | 100 |

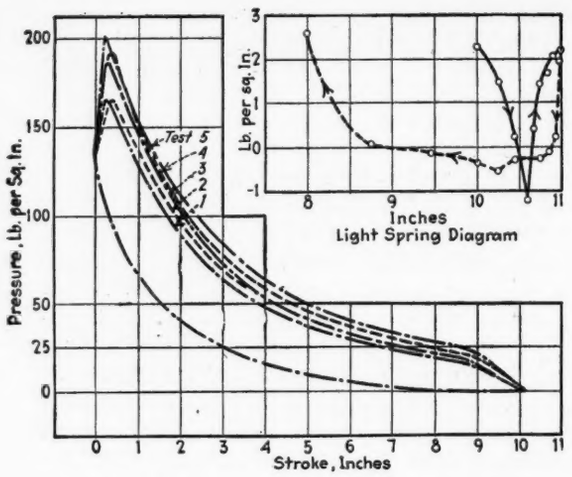



*Fig. 6—Point-by-point indicator diagram*

All of the tests described were made by Professor Allcut under the auspices of the School of Engineering Research, in the Department of Mechanical Engineering of the University of Toronto.

## Reduction of Investment in Boiler Equipment Per Kw. of Station Output*

REDUCTION of investment in steam-generating equipment falls into two distinct classes: The reduction in investment per unit of installed capacity, and the reduction in the amount of spare capacity.

Advances in the design of fuel-burning equipment have been such as to permit the burning of a greatly increased amount of fuel in a single boiler unit. About five years ago the ability of furnace walls rather than fuel-burning equipment to stand punishment became the limiting factor in boiler output. Since that time the use of water-cooled furnace walls has definitely eliminated refractories as a limitation. Moreover, the use of water walls has decreased the danger of burning out tubes by decreasing the maximum rates of heat transfer because of the increase in the amount of water-cooled surface which "sees" the fire.

In addition to those improvements which have made it possible to carry on much higher rates of evaporation, there have been several other advances which make it possible to increase the total amount of steam produced by a single boiler unit. Longer boiler tubes are being used, and the total width of boilers is being increased incident to the ability of the manufacturers to fabricate longer drums.

The two trends, one toward the increase in the average rate of evaporation per square foot of boiler surface, and the other the increase in total amount of heat-absorbing surface, have resulted in a material increase in the maximum capacity of individual boiler units. Today there are at least 24 boiler units, either in operation or in the course of construction in this country, supplying steam for a total of 35,000 to 40,000 kw., and three of these units will each be capable of supplying the steam required for 75,000 kilowatts.

*Abstracted from report of N.E.L.A. prime movers committee.

# Good Plant Management Depends on Care of Instruments

**This and other instructions published in *Power* from the pen of Mr. Polakov set up standard management practice for the important jobs and functions involved in the operation of a power plant. The author has written these as a result of many years of experience. Power plant managers will find them valuable guides.**

By Walter N. Polakov*
*Consulting Engineer, New York City*

*INSTRUMENTS in the power house, particularly in the boiler house, constitute the nerve system of the organization. With nervous reactions deranged, the activities are haphazard, disorganized and often dangerous, and ultimately bound to self-destruction. The proper array of instruments is capable of telling operators what to do, when to do it and how to do it. If instruments are permitted to get out of adjustment or deteriorate, the plant is like a man who has lost his sight, smell or hearing—he takes chances. It is of utmost importance therefore to keep all instruments and recording apparatus continually in the best possible condition.*

*The schedule for periods between inspection and limits of allowable errors, as given, is only approximate, as observed in a large variety of plants using such instruments. The methods of test are merely suggestions of principles, since the details are invariably given by the manufacturers of such instruments. It is desirable that graphic reports of every test, showing deviations as found and as left, be made and filed together with the repair record cards and for the same purpose.*

*With complete equipment of recording instruments, an old-fashioned power house log is supplanted by autographic charts and daily summaries.*

## Inspection and Care of Instruments

*General:* Without instruments guiding operation and recording conditions and performance, power plant operation is only hit or miss—not engineering. With instruments out of order, it is always a losing game: loss of operating economy and loss of investment in instruments.

*Object:* Scheduled inspection, cleaning and periodic overhauling help to maintain instruments accurate and avoid repairs during their use.

*Responsibility:* The chief engineer is responsible for continuous and correct records and indication by all instruments in the power department. He may delegate the necessary authority to an expert from the concern manufacturing the instrument or to the power plant maintenance man, or request aid from the mechanical department; *but* in all cases he is responsible for accurate indications and readings.

*Schedule:* Periods for inspection and overhauling of different types of instruments are recommended below. After each instrument has been gone over, a tickler [see standard practice on tickler to be published in *Power* at a later date] is prepared and dated three days in advance of the next scheduled inspection.

SCHEDULE OF INSPECTION

| Symbol | Class | Period Between Inspections | Limit of Error |
|---|---|---|---|
| S | Scales | 3 months | ± 1 lb. |
| F-g | Flow meters, G. E. | 1 month | ± 3% |
| F-z | Flow meters, Republic | 6 months | ± 1.5% |
| F-b | Flow meters, Bailey | 4 months | ± 1.5% |
| F-v | Flow meters, Venturi | 3 months | ± 2% |
| G-s | Gages, steam | 3 weeks | ± 1 lb. |
| G-p | Gages, pressure | 2 months | ± 1 lb. |
| G-v | Gages, vacuum | 2 months | ± 0.5 in. |
| D | Draft gages | 1 month | ± 0.1 in. |
| T | Thermometers | 6 months | ± 2° F.; 1° C. |
| P | Pyrometers | 6 months | ± 3% |
| A | $CO_2$ recorders | 2 weeks | ± 0.5% |
| E-a | Ammeters | 6 months | ± 3% |
| E-v | Voltmeters | 6 months | ± 3% |
| E-w | Wattmeters | 6 months | ± 3% |
| C | Clock mechanisms | 1 month | 3 min. per 24 hr |

*Reports:* The tester must report the results of the test of each instrument, using cross-section paper, with useful range of readings marked both horizontally and vertically. A diagonal thus represents a zero error line. If the tested instrument reads below or above, the test curve will also show either below or above the diagonal.

When an instrument is adjusted or repaired, the new test line must be plotted again on the same chart and the date written. These reports are filed for reference.

### Methods of Test

S—By standard deadweights plus or minus 2 lb.

F—Flow meters calibrated against the water gage or column (U-tube). For details see General Electric company's, Bailey company's, or Republic company's booklets.

F—Venturi meters—in parallel with calibrated flow meter or by weighing discharge at observed temperature.

G—Against deadweight tester at least quarterly. Monthly check permitted against inspector's standard gage.

V—Against Torricelli's tube or mercury column.

D—In parallel with U-tube filled with pure water or differential gage calibrated against such U-tube.

T—Against standard thermometer submerged in an oil bath at service temperature. No melting ice or boiling water to be used except in laboratory.

P—Pyrometers, if error is shown, shall be checked against another couple and couple against standard milliammeter.

E—See rules of A.I.E.E. or N.E.L.A.

C—Chart shall be drawn for 24 hr. Readings to be made at the start and 24 hr. after by a chronometer and recorded on the chart by an up-and-down pen line. Clock speed to be checked against chronometer or accurate watch three times in 24 hr., every 8 hr. by marking line with chart drawing pen on the chart as moved by the clock.

I—Indicators and springs tested as required. Use either deadweight tester as for steam gages or standard gage on T connection with the indicator fully assembled.

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# *Right Out of the Plant*

## Measuring the Clearance Volume of a Corliss Engine

RECENTLY I had occasion to measure the clearance volume of an 8 x 18-in. Corliss engine in connection with a test run to obtain data from which a Hirn's analysis could be made. It was not possible to obtain the clearance volume from the engine builders.

First we removed the cylinder head. As was to be expected it was not feasible to calculate the clearance volume from the measurements taken, due to the irregular shape of the steam and exhaust ports. It was decided that the best method to obtain the clearance was by filling with a measured quantity of water. The cylinder head was replaced and a short length of pipe was connected vertically in the place where the engine indicator is ordinarily placed. This was done to get sufficient head to completely fill the cylinder. The engine was placed on the head-end dead center and the steam valve was opened so as to permit the escape of the air trapped in the clearance space as it was filled with water. Measured quantities of water were poured in the vertical section of pipe on the indicator connection.

After several attempts it was found impossible to get reliable results in this way. As the water neared the top of the cylinder it would leak past the piston, which, owing to wear, would rest on the bottom of the cylinder and leave a small space at the top of the cylinder where the water could leak past the piston. Also it could not be determined when the steam port was just full and when the water had begun to fill the steam chest. Consequently the method of filling the clearance space completely full was unsuccessful.

The cylinder head was again removed and the height of the center of the cylinder above the engine base was determined. It was found by subsequent measurements that the center of the indicator connection was at the exact center of the cylinder. It was also found that the shape and size of the steam port and the exhaust port were identical. This condition, I think, will be found on most Corliss engines. The cylinder head was replaced. A measured quantity of water was poured into the indicator connection until its level was at the exact center of the cylinder. As the steam and exhaust ports were of the same size, the volume of water added was one-half of the clearance volume. We repeated this several times, finding the volume of water required to fill one-half of the clearance space was the same for each determination. The crank-end clearance volume was determined in the same way.

MERL D. CREECH.

Oklahoma City, Okla.

## Claims Priority Over Benson

WILL you please be kind enough to insert the following statements in *Power*. They are to define my attitude regarding the article "Benson Boiler Versus Loeffler Boiler," by H. W. Queisser in the June 4 number. My investigations and results from 1913 were described in *Power*, Jan. 15, 1924, under the heading "A Predecessor of the Benson System."

I know of no publication whatever on these matters before 1913, either in the physical or in the technical literature, which had stated the proposition as clearly as did my study of the entropy diagram of the "circular process" at the critical pressure—then supposed to be 204 kilograms per square centimeter (2,900 lb. per sq.in.). [See W. Schüle, "Mechanics of Heat," published by Springer, 1909 edition, page 229]—and which had predicted the extraordinarily high thermal efficiency of 43 per cent (today commonly accepted) by superheating steam to 427 deg. C. (800 deg. F.). I am therefore entitled to claim for myself the priority in the determination of the "circular process" at critical pressure, as described in my article published October, 1913, in periodical No. 42 of the *Oesterreichischen Ingenieur-und Architektenverein* (Austrian Society of Engineers and Architects).

My entropy diagram for critical pressure, published in 1913, is identical with Benson's entropy diagram in the British patent specification 201,296 of May 15, 1922, especially with *A', A B D G G'* in the Benson diagram. It is therefore beyond doubt whose is the priority in considering generation of steam at the critical pressure. It is of no importance that Benson obtained the patent and not I myself. I applied for the patent on the circular process at the critical pressure of 204 kilograms per square centimeter at Vienna on Sept. 24, 1913, under No. A 8210-13 resp. 49064, which I can prove by legal documents. In these documents the boiler construction I wished to have patented is described as follows:

"A boiler construction wherein a progressive movement of the water in a system of tubes exposed to the heat source is chosen instead of the usual constant circulation of the water in the boiler. For this purpose the water is fed on one end of the tube system and on the other the steam is taken saturated or superheated."

I did not then obtain the patent, chiefly because I was too inexperienced in patent matters to defend my rights energetically. In 1926 Benson could not obtain his patent in Austria in the form in which he wished to take it out because of my objections. His patent was limited to the throttling of the steam from the critical down to lower pressure.

In 1913 a pressure of 2,900 lb. per sq.in. was taken as critical pressure. In 1922 Benson fixed on 3,200 lb. According to the latest researches by H. L. Callendar (*Engineering*, Nov. 3, 1928) the critical pressure is 3,650 pounds.

Under these circumstances, the following question would be very interesting: Is a boiler, working at 3,200 lb. per square inch with progressive water and steam movement, in one or several tubes, a Benson boiler or is it not?

Mahrisch Ostrau, Czechoslovakia.

DIPL. ENG. DR. J. HAVLICEK,
*Chief of the Mechanical Dept.,*
Vitkovice Collieries.

[It is impracticable here, because of space limitations, to reproduce or translate the patent application or the article published in 1913 by the Austrian Society of Engineers and Architects. This article was mentioned in *Power*, Jan. 15, 1924, and a photographic copy has been furnished by Dr. Havlicek.—EDITOR.]

## Simplifying Recorder Charts

IN THE larger factories and plants there are usually numerous recorders of the circular-chart type, often of various makes. These charts are sometimes filed in a vertical position on pegs on the wall, where they may be easily examined. When they are filed in this position, with the spaces for the date-of-use stamp and one's own figures in an upright position, 12 o'clock midnight will be at as many positions as there are makes of chart.

It seems to me that recorder manufacturers might get together and print all their 24-hr. charts with 12 o'clock midnight at the top.

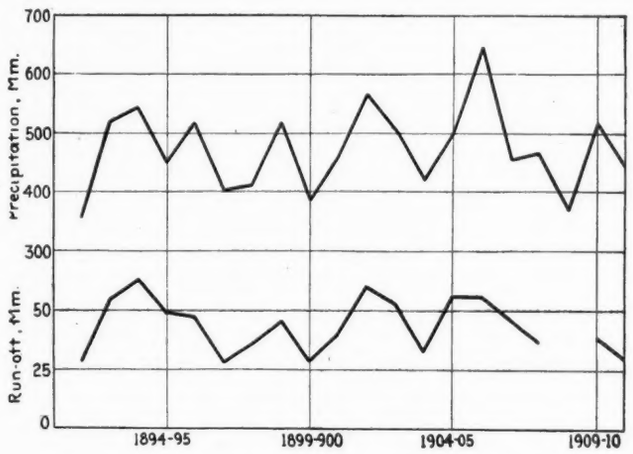
W. E. HENTHORN.

Dolbeau, Quebec.

## Stream-Flow Prediction for Power Generation

THE PAPER by Mr. Streiff, "Forecasting Water Supply for Hydro Development," in the issues of *Power*, April 16 and 30, is of great interest to engineers who deal with the problem. The correlation described seems at first too general and undefined for practice, but it may prove effective after it has been worked out on the basis of numerous data. My own conclusions in this line derived from the investigations on the Dnieper River, beginning 1852, confirm fairly closely Mr. Streiff's ideas on the double sun-spots cycle.

In connection with river developments, many engineers are interested in runoff forecasting, but more particularly for low-water periods. In this direction I have made an attempt which proved rather successful. Low-water foreknowledge is important for large plants operated independently. The watershed area in such cases is large. I had an idea to determine for the site of the plant the lag of runoff, excluding spring months of high water and precipitation falling as snow. This lag as found for a basin area of 174,000, 39 square miles, was 9.5 months.




*The runoff curve is displaced 9.5 months behind the precipitation curve*

The correlation is shown in the figure, where runoff data are displaced 9.5 months behind the precipitation, which brings the two curves into quite close relation to each other. The coefficient of correlation equals 0.83, which is very high. This connection gives the possibility to forecast, after careful investigations, the runoff for low-water periods from precipitation taken about a year ahead.

Moscow, U.S.S.R. T. MARETSKY,
*Chief Hydrogist,* Nijne Dnieper.

## Turbine Vs. Engine for Non-Condensing Operation

THE writer wishes to comment on the replies appearing in the Aug. 6 issue to the question "For non-condensing operation with 200-lb. gage, 100 deg. F. superheat at the throttle, should a 500-kw. unit be a turbine or reciprocating engine?" Some of the advantages of each type of unit were well brought out in the answers, although a lack of knowledge of comparison of the two units also was indicated. It is to be regretted that the question did not give more information on the amount of steam required for manufacturing purposes. As it stands, two different conditions must be assumed and the decision given for each.

As the first case assume that all the exhaust steam, regardless of the steam rate of the prime mover, can be utilized in manufacturing. In the second case assume that the total steam demand and fuel consumption is determined mainly by the efficiency of the prime mover.

For the contributor who is doubtful of lubrication at the steam temperature of 488 deg. F., it may be stated that reciprocating engines are being lubricated satisfactorily at temperatures around 800 deg. F. In many of the answers reference was made to the oil in the engine exhaust where such steam is used in process. In such cases provisions for removing this oil from the steam should be considered, or an engine unit be selected that requires no internal lubrication. Such procedure represents no new undertaking. Engines using steam at 350 lb. pressure are operating successfully without any internal lubrication. An engine unit will take up more space than a turbine, but with some types of engine the difference is not great.

Referring to the second assumption: If the larger boiler room and greater storage space for fuel and ashes of the turbine plant are considered, the net advantage in space may be reduced to zero or in favor of the engine.

It will be noticed that the writers do not all agree as to the comparative steam rates of the two types of prime mover. This difference may be due to the different classes of units that they had in mind. For instance, it would be possible to select a high-class turbine having a lower steam rate than a low-class engine. For units of comparative class there is, without any chance for argument, a decided difference in favor of the engine unit. Under average working-load conditions, with the steam range and unit capacity given, the steam consumption of the engine generally will be found to be around 15 to 20 per cent less.

As to comparative costs, all agree that the engine unit will cost more than the turbine unit. In referring to the second case, the cost of the boiler room will be dependent upon the steam demand, which for the engine is 15 to 20 per cent less. The difference in boiler room costs will be much more than the difference in prime mover costs, so that the complete engine plant will cost less than the complete turbine plant.

In the first case the advantages of one unit just about balance the advantages of the other unit, so that a decision in prime movers may be a matter of opinion.

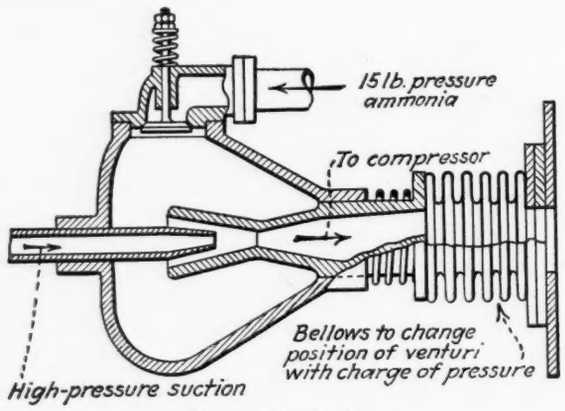
In the second case, with the advantages in plant costs and total space occupied reversed in favor of the engine plant, longer life of unit, better overload and underload operations, together with a 15 to 20 per cent lower fuel consumption, the decision of an engineer or business man will be with the high-class engine unit.

Chicago, Ill. JOHN F. FERGUSON.

## Multiple-Effect Compression

IN reading an article on multiple-effect compression by Frank P. MacNeill in *Power,* May 21, it struck me that an invention of mine in air compression might interest refrigeration men.

When letting in the high-pressure vapor at the termination of the suction stroke of the low-pressure vapor, why not use a venturi compressor, or aspirator, to drive in the low-pressure gas at the same time the high-


15 lb. pressure ammonia
To compressor
Bellows to change position of venturi with charge of pressure
High-pressure suction

*Suggested device*

pressure gas is going in. You might be able to drive in 30 per cent more low-pressure vapor, with a considerable saving of high-pressure vapor. The pressure could, if desired, be taken up to the high-pressure suction pressure, and the temperature would be a good deal less than that of straight compression. The illustration shows how the arrangement could be made.

Vancouver, B. C. EDWARD MAHON.

## Metal Polish Used to Clean Circuit-Breaker Contacts

MANY operators are not acquainted with some of the small details concerning air circuit breaker maintenance. The question of cleaning is one detail which should be stressed. Aside from blowing the dirt out of the mechanism with compressed air, the cleaning of the contact surface is of even greater importance. An accumulation of oil vapor and dust on the contact surfaces increases the temperature rise of the breaker, assuming that the major features of maintenance, such as alignment of parts and proper contact pressure and area, have been properly looked after.

The use of sandpaper should be avoided on the main contact surfaces, as it grooves the area and increases the amount of dirt retained, likewise a considerable amount of metal is removed, and in time the flat surface is destroyed. Metal polish is the better material with which to clean the contact surfaces. It should also be used to clean telephone switchboard plugs, potential and current plugs and knife switch blades or in any place where a loss of metal will destroy the fit of current-carrying parts that must be kept clean to prevent high-resistance.

In some of the older designs of auxiliary switches used with air break circuit breakers for the operation of interlocks and signal lights the contact springs do not have sufficient strength, and become inoperative. Generally this trouble can be eliminated by making new spring contacts from phosphor-bronze spring stock of slightly thicker section than the old contacts.

All nuts and screws should be examined and tightened every month. At times loose contacts cause faulty operation of the control of remotely operated breakers, and may cause considerable damage to equipment. When tightening terminals on control wiring it is essential to try the wire under the screw or nut when cup washers are employed. These washers may become sprung, and the pressure is insufficient to grip the wire. Unless the wires are held securely, loose contacts in the control wiring will be found after three or four operations of the motor-driven closing devices on oil circuit breakers. Regular periodic inspections are essential, and proper lubrication is paramount on all motor-operated devices if operating failures and interruptions to service are to be avoided. J. ELMER HOUSLEY.

Alcoa, Tenn.

## Mechanical Stresses Seen as Chief Cause of Cracks in Boiler Plate

REFERRING to the article by J. M. McCabe, p. 148, July 23 issue of *Power,* it would appear that an error has been introduced in connection with the discussion of drum circumferences (at the bottom of the second column). It would be more correct mathematically to use a plate with 3.1416 $(D + t)$ as the circumference of the neutral axis, $D$ being the internal diameter, $t$ the thickness of the plate and $D + 2t$ the external diameter.

Oak Park, Ill. E. S. SMAIL.

The above letter was submitted to Mr. McCabe, who replied as follows:

Mr. Smail is right in his suggestion that the formulas for drum circumferences were erroneously expressed. The calculation should be $(48 + 0.6875) \times 3.1416 = 152.9566$ in. for the width of plate to roll a 48-in. diameter drum. The circumference of the internal surface would be 150.7968 in. The external circumference for a drum 0.6875 in. thick would be 155.1165 in. The internal surface would be reduced 2.1598 in. and the external surface elongated 2.1599 in., provided that both surfaces of the plate were of the same hardness.

To strain the outer surface to the yield point the elongation would be about 0.1529 in. The neutral axis circumference would remain about 152.9566 in.

The reference was intended to call attention to the stresses set up in forming boiler plates. It will be seen that the inner surface has been upset over 14.11 times the amount of change of length necessary to strain it to the yield point, and that the external surface has elongated by the same ratio. J. C. MCCABE.

Detroit, Mich.

## Corrosion of Evaporator Coils

THE top evaporator coils in one of our brine tanks became seriously corroded, but only the tubes just below the surface of the brine were affected.

The brine return to the tank discharged a few inches in the air above the brine, and the cause of the corrosion was traced to the fact that air was carried down with the falling brine and brought in contact with the top tubes, the action of this air causing the corrosion. This trouble was rectified by carrying the brine discharge down below the surface of the brine. W. E. WARNER.

Brentford, England.

# *What's New in Plant Equipment*

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

## Elevator Guide-Rail Lubricator of the Grease Type

LUBRICATING guide rails by hand is one of the most disagreeable and hazardous jobs in the maintenance of elevator machines. Not only does it require the services of two men to do the job, one to operate the elevator and another to ride on top of the car to do the greasing, but the elevator must be taken out of service when the work is done. Another objection to hand greasing is that the rails either have a feast or a famine of lubrication. There is generally too much grease on the rails when the lubricating is first done and after the machine is in operation a while the rails are dry. The answer

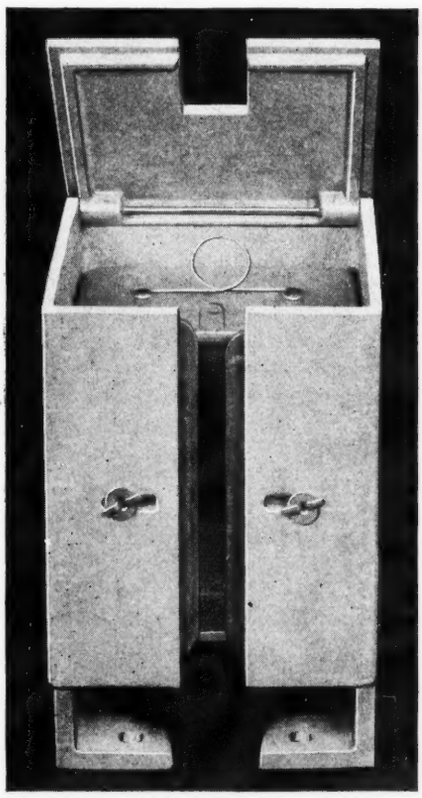


*Fig. 1—Lubricator with its cover raised*

to these and other objections is—automatic lubrication.

An automatic guide-rail lubricator shown in the figures has recently been developed and placed on the market by Yvan Zenon, 244-22 136th Ave., Rosedale, N. Y. This device is designed to use a light grease as the rail lubricant and is mounted on the upper end of the top guide shoes on

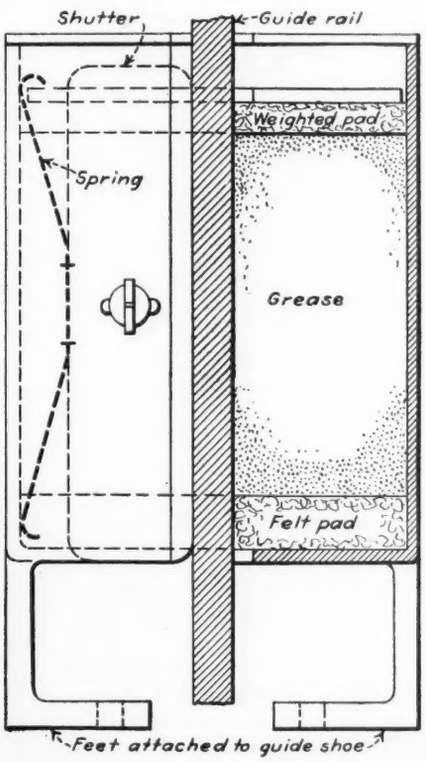



*Fig. 2—Section through lubricator, showing construction*

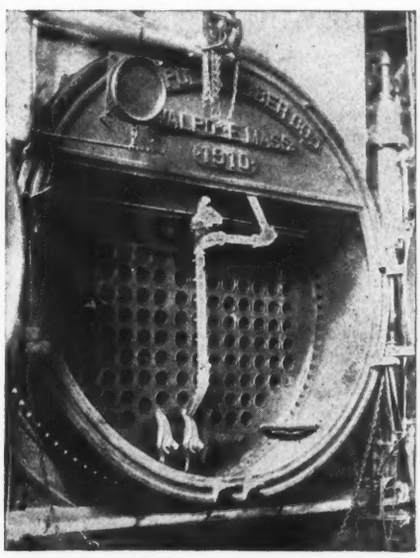
the car and counterweights. A light grease and graphite compound is recommended by the manufacturers of the lubricator for greasing the rails. The grease is packed around the guide rails and is applied to them by the movement of the car and the counterweights. Each lubricator holds about two pounds of grease, which is sufficient to grease the rails for one year on an elevator as operated in the average office building.

The lubricator consists of an oil chamber designed to fit onto the guide rail and bring the lubricant in contact with the three working faces of the rail. There is a felt pad as shown in Fig. 2 at the bottom of the grease reservoir. It acts as a packing to keep the grease in the reservoir and also to prevent an excess from getting on the guide rail. On top of the grease is a weighted pad to keep the grease in contact with the rail and to prevent too much grease being supplied to the rail when the lubricator is moving down. Two fiber shutters, one of which is shown in Fig. 2, make a tight joint with the guide rail and completely close the reservoir on the rail. These shutters are held to the rail with springs that allow side motion of the guide shoes without interfering with the seal of the lubricator with the rail.

This lubricator supplies grease to the guide rails only when the car is in motion. The action is much as if the grease were applied by a soft brush rubbing on the surfaces of the rail. The device is adapted to either slow-speed or high-speed elevators, and is in use on cars operating at speeds as high as 750 feet per minute.

## Return-Tubular Boiler Tube Cleaner

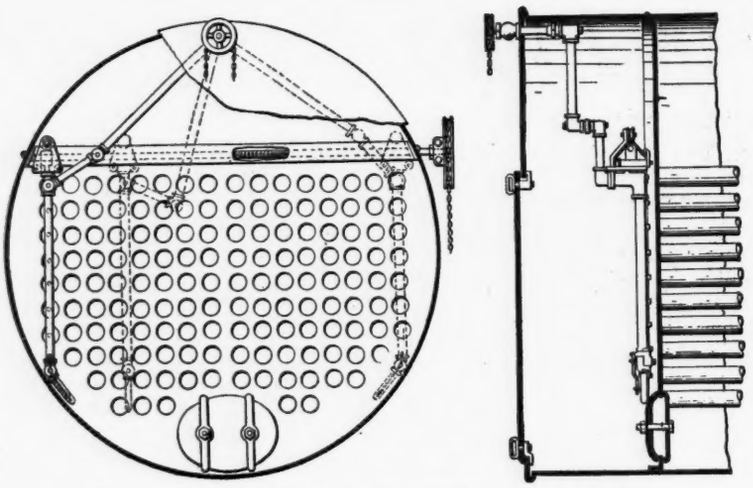
EFFECTIVE cleaning by the use of a straight blast through the tubes with high velocity and the entrainment of a maximum amount of



*Cleaner in position in boiler*

air or gas are among the claims made for the "King Cole" soot blower now being put out by Wheelock-Bogue, Inc., 25 Huntington Ave., Boston, Mass.

The cleaner is designed especially



*Cleaner has straight-line movement across the tubes*

for use with horizontal return-tubular boilers and to have a straight line movement across the tubes. It consists of a steam header with a series of properly spaced nozzles supported by an overhead trolley and connected through a flexible connection to a steam line at the upper center of the boiler head, as shown. The movement of the nozzle group across the head is effected by the use of a screw and a nut in the body of the trolley, the screw being turned by means of a chain and wheel at the side of the boiler. The steam valve is also operated from the floor by means of a chain. The trolley, or nozzles, support travels on an angle placed horizontally above the top row of tubes, as shown in the right-hand view of the cross-section.

The space between the ends of the nozzles and the tube ends is such as to give maximum entrainment of air and maximum velocity through the tubes.

When not in use the cleaner is run to one side of the boilers, where it offers minimum resistance to the flow of gas through the tubes.

## Automatic Scale for Weighing Materials in Transit on Conveyor

AN AUTOMATIC scale, designated "Telepoise," for continuously weighing coal or other material in transit on conveyors has been developed by John Chatillon & Sons, 89 Cliff St., New York.

The machine consists of a steel framework the lower part of which, as shown in the illustration, is a suspended type of scale. Two carrying idlers of the belt are mounted on the floating platform, over which the belt travels with the load.

The weighing mechanism consists of a scale beam balanced by means of calibrated springs. Beneath the end of the beam is the integrating mechanism, consisting of two drums which are caused to revolve toward each other at a speed proportional to that of the belt, by means of the traction roller and transmission.

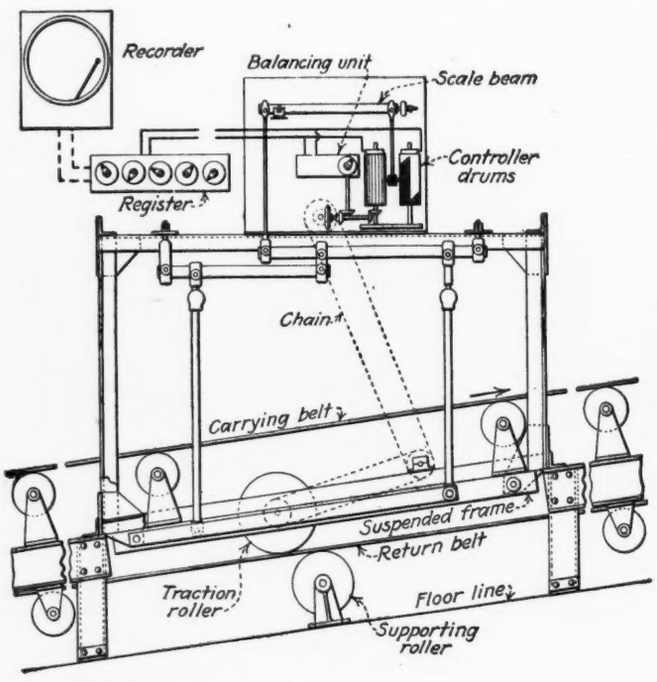
The left-hand drum surface is milled into a succession of cams, while the right-hand drum has a smooth surface one-half of which is metallic and one-half non-conductive. The dividing line between the metallic and non-conductive surfaces is part of a helix, so that the surfaces are like two equal right-angle triangles wrapped around a cylinder and fitting together along the hypotenuse.

As the drums revolve a contactor suspended from the end of the weigh beam and moving in unison with it is vibrated rapidly against the surface of the drum on the right by the cams on the surface of the left drum and when brought in contact with the metallic surface of the right drum opens and closes an electric circuit. The impulses occasioned thereby, through the brushes at the top of the drums and wiring, operate an electro-mechanical device which is geared to a continuous register at a ratio to convert the impulses into pounds, tons, barrels, etc., as desired.

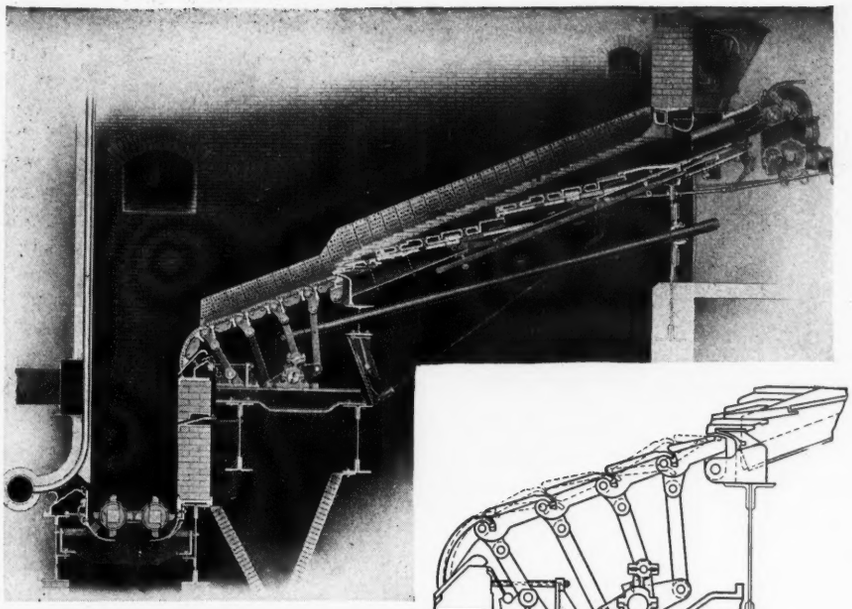
A 24-hour chart recorder is operated by wiring from the register. The register and recorder may be installed at any distance from the machine or from each other.

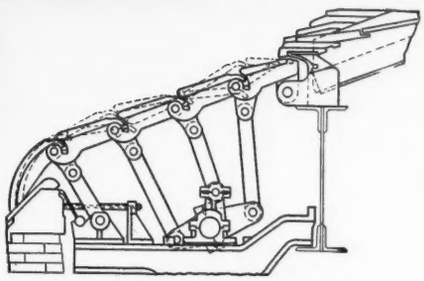
A load-indicating device is incorporated which by means of a projector of the lantern type throws an intense spot of light with a black line in its center onto a ground glass scale divided into 100 parts. At no load the black line rests at zero; at full load 100.

To balance the machine a lever is used to transfer a small weight to the weigh beam and automatically cut out the load register; the controller is simultaneously connected electrically to the balancing unit, which is so arranged that it will indicate whether or not the machine is in balance, and if not, what adjustment is necessary.




*General plan of scale showing arrangement of weighing, integrating and recording mechanisms*





*Cross-sectional view and detail of undulating section*

## Improved Multiple-Retort Stoker With Undulating Overfeed Section

A DISTINGUISHING feature of the latest design of multiple-retort stoker put out by the Westinghouse Electric & Manufacturing Company, Philadelphia, Pa., is the employment of a flat undulating link grate surface forming a large overfeed section immediately adjacent to the underfeed retorts.

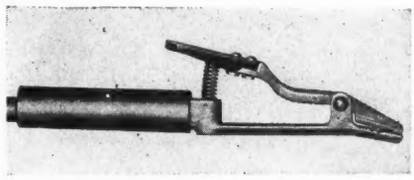
This section of the grate receives fuel and refuse discharged from the retorts and has sufficient surface to burn a large quantity of coal. The motion of the undulating overfeed element is controlled separately from that of the retort rams. This permits regulation of the ash discharge to the clinker grinder pit without interfering with the distribution of fuel in the retorts and over the tuyeres.

The unit shown in the illustration has a capacity of about 3,000 lb. per retort per hour. The line drawing shows the action of the link-grate overfeed section, the extent of the movement of the various sections being indicated by dotted lines.

## New Holder for Welding Electrode

AS A SUPPLEMENT to its line of electric arc-welding equipment, the General Electric Company, Schenectady, N. Y., announces a clamp-type electrode holder. The new holder has jaws of heavy copper alloy, notched for any size of electrode wire from $\frac{1}{16}$ to $\frac{1}{4}$ in. in diameter, in any position.

A molded compound handle protects the operator from heat and from contact with current-carrying parts.



*Clamp type electrode holder*

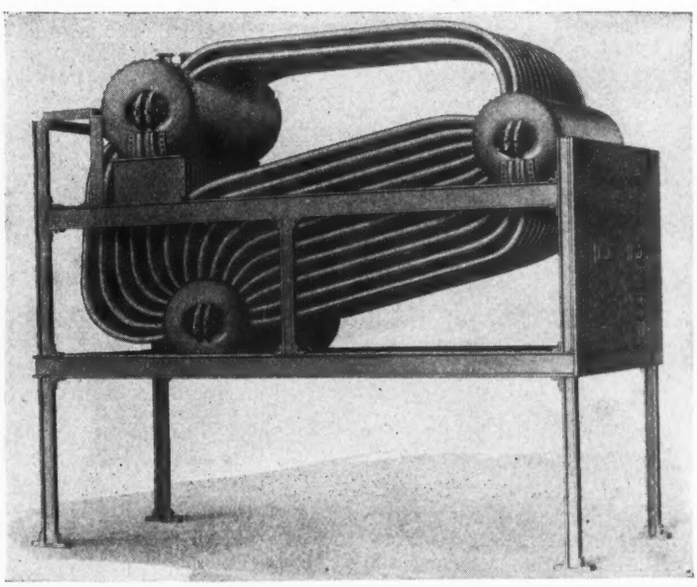
The holder is designed for use with currents up to 300 amp. and may be obtained, if desired, assembled with five feet of flexible cable and a terminal.

## Low-Head Water-Tube Boiler

TO MEET the need for a small water-tube boiler for locations having limited headroom and floor space, the D. Connelly Boiler Company, of Cleveland, Ohio, has recently developed the low-head boiler illustrated below. Sizes range from 750 sq.ft. of heating surface up to about 3,500 sq.ft. and are suitable for small industrial plants and heating purposes.

As shown in the illustration, the boiler consists of three drums interconnected by banks of tubes. The feed water is introduced into the rear upper drum, where it enters a feed pan and is distributed the entire length of the drum. The water then passes down through the rear bank of tubes to the bottom drum, from which it enters the path of circulation. Steam and water pass from the front circulating drum to the rear upper drum through two rows of tubes; here the steam is disengaged, leaving the boiler through the steam-outlet nozzle on the top of this drum. The boiler is supported directly on the steel frame by brackets riveted on the ends of the upper rear and front drums, as shown in the illustration. The lower rear drum is supported directly by the tubes.

The boiler is adaptable for a furnace designed for any standard type stoker, for hand firing, as well as for oil and gas burning. The smaller units can be shipped completely assembled, and any part of the larger boilers will pass through a four-foot doorway when shipped "knocked-down."



*Low-head boiler erected on steel frame*

# FROM AMONG READERS' PROBLEMS

*Conducted by* L. H. MORRISON

PIPE FLANGE BOLTS—*Why are flange bolts now threaded over the entire length. Would not breakage be less if the center portion of the length were reduced in diameter?* F. H. C.

It has been found that under the high stresses existing in modern flange bolts there was a tendency for the bolt to break at the point where the thread started. By threading the entire length there is no change in material along the direct lines of stress. This method is superior to the reduction of diameter in the center of the bolt length.

HEATING WATER—*How many pounds of exhaust steam will be needed to heat 5,000 gal. of water per hour from 60 to 180 deg. F., in a 500-gal. storage heater. The exhaust steam is at 3 lb. gage.* G. M. P.

A gallon of water weighs 8.33 lb., making the total weight of water 5,000 × 8.33 = 41,650 lb. The specific heat of water is 1; that is, it takes 1 B.t.u. to raise 1 lb. of water 1 deg. F. To raise 41,650 lb. from 60 to 180 will require (180 — 60) × 41,650 = 4,998,000 B.t.u. For ordinary calculations it can be asumed that the steam leaving the cylinder is dry saturated when it has dropped to the back pressure of 3 lb. gage. It will be assumed that the condensate in the heating coils corresponds to the pressure, that is, 222 deg. F. Each pound of dry saturated steam at 3 lb. gage, or 17.7 lb. abs., has a total heat of 1153.5 B.t.u. The condensate at 222 deg. has a heat content of 189 B.t.u. The difference, 1153.5 — 189 = 964.5 B.t.u., is transmitted to the water being heated. One would need 4,998,000 ÷ 9,645 = 5,182 lb. of steam.

OPERATING TWO COMPRESSORS ON ONE SUCTION LINE—*We have two horizontal refrigerating machines placed side by side, and the brine tank is farther away from one than the other. In running two machines together, we cannot get them to perform the same work. We must run the machine farther from the tank much faster than the one nearer the tank to enable both to get an equal charge of ammonia. The suction pipe from the expansion coils does not enter the line midway between the two machines. Is there any way of running these machines so as to get them to work the same?* E. G. M.

At the tee leading to the suction of the nearer compressor a certain pressure exists. As the pressure drop from friction is in proportion to the pipe length, the gas will naturally flow to the nearer compressor. To compensate for this the farther machine must be run fast enough to create a pressure difference in its suction line that will induce the gas flow to it.

By adjusting the suction-globe valves of the machines the pressure drops in each line can be made equal.

POWER DEVELOPED BY FALLING BODY—*An airplane tire weighing 50.5 lb. drops off when 1,500 ft. above ground. What are the foot-pounds of work done and the horsepower when it lands? What force is exerted when the tire strikes the ground?* B. K. M.

The foot-pounds of work that a falling body will do on coming to rest is equal to the work required to elevate it to its position before falling. The weight is 50.5 lb., the height is 1,500 ft., consequently the foot-pounds of work that the weight can release on striking the ground is 50.5 × 1,500 = 75,750 ft.-lb.

This is the work that is used up as the body penetrates the earth, or, let us say, indents it, and when the body comes to rest the work has all disappeared, reappearing as heat.

Work = force × distance. If we assume that the body actually penetrates 0.1 ft. then 75,750 = force × 0.1, or force = 757,500 lb. = 378.75 tons. But this is the average force and the maximum force, which exists at the instant of penetration, is twice this, or 757 tons.

This is on the assumption that the body is non-elastic and all the change occurs in the earth. Actually the deformation occurs almost entirely in the tire, if the ground is firm. It is then necessary to assume the tire deformation, if it is not known.

The horsepower released when it strikes the ground depends upon the time taken to bring the tire to rest after contact, which time must be assumed.

POWER REQUIRED FOR A STATIC CONDENSER—*Is there any way of knowing how much power it would take to run a 120-kva. static condenser that corrects the power factor from 0.67 to 0.84?* G. M. P.

The power expended in the operation of a static condenser is the losses in the unit. If the condenser is connected directly to the line these losses will be about 3.5 watts per kva. capacity. If the condenser is connected to the line through transformers, such as when 2,300-volt condensers are connected to a 220-volt line, the losses will be about 30 watts per kva. Then if the 120-kva. condenser is connected to the line the power taken by it will be about 120 × 3.5 = 420 watts. On the other hand, if the condenser is connected to the line through a transformer the losses will be approximately 120 × 30 = 3,600 watts. The range over which the power factor is corrected does not affect the power taken by the condenser. The losses will be about the same when the power factor is corrected from 0.60 to 0.90 as when the correction is from 0.67 to 0.84.

# PREVIOUS QUESTION

## DISCUSSED BY READERS

### THE QUESTION

*WE ARE operating a number of synchronous motors on a system with an induction-motor load. There has been considerable discussion in our operating department as to what value of power factor the synchronous motor's field current should be adjusted, to obtain the most economical operation.*

P. W. P.

TO WHAT power factor the synchronous-motor field current should be adjusted depends on two things, the proportion of synchronous motor capacity to that of the induction motor and the power factor desired on the system. With one extreme, the capacity in synchronous motors cannot possibly boost the power factor above the value desired, and in this case the motor field would be made as high as possible without overheating. At the other extreme, such as where the synchronous-motor capacity is much greater than the induction, so that power-factor correction is not especially needed, the field current may be set to give unity or slightly leading power factor at full load. This enables the synchronous motor to carry its load with the least heating.

Between these points it is necessary to decide, first, what value of system power factor is most economical and, second, how much leading reactive kilo-

volt-ampere is necessary to attain this. Losses in one's own equipment and power factor penalties, if any, determine the desired power factor. The lagging reactive kilovolt-ampere of the induction motors may be computed and the fields adjusted to give the proper leading value, or a power-factor meter may be installed on the main line and the fields adjusted accordingly.

F. Fraser MacWilliams,
Pennsylvania Coal & Coke Co.
Cresson, Pa.

I DO not believe there are many installations that can be classified alike, but each installation requires individual consideration, due to the location of the power-factor corrective machines being an important factor in determining the amount of field excitation necessary to produce most efficient results.

Assuming that power-factor correction affects a considerable amount of metered network, it would be advisable to operate the synchronous motors at maximum field excitation, thereby eliminating the line and transformer losses, which would otherwise be caused by excessive current carried by the low power factor.

It is quite evident that carrying a high power factor on a synchronous motor located within a short distance of the service meters proves inefficient, considering the difference between exciter power and the $I^2R$ losses of the short power line, especially when the power is metered on the secondary side of the transformer.

A summary of the above facts shows that when synchronous motors are located near the "reactive center" it is advisable to carry maximum excitation.

W. M. Meineke.
Bayonne, N. J.

THE efficiency of alternating current will decrease with a decrease in power factor whether the current is leading or lagging. If the power is purchased on a kilowatt basis and no penalty is imposed for low power factor, it would be advisable to run the synchronous machines as near unity power factor as possible. A leading power factor on these machines would benefit only the power company.

If a penalty is imposed for low power factor, it is advisable to regulate the current in the synchronous machines to an amount leading, so that the gain in dollars brought about by no penalty is greater than the cost of the increased wattage loss caused by running the machines at a lower efficiency.

If the company generates its own power it is advisable to keep the generator power factor near unity, since the square of the generator current will probably be greater than the sum of the squares of the motor currents, and it is upon the $I^2R$ loss that the efficiency of the plant depends.

The above statements are general. It is necessary to calculate just what the most economical power factor is for the synchronous machines in each plant.

Gordon R. Hahn.
Westfield, N. J.

THERE is no practical change in efficiency of a synchronous motor over a reasonable range between an underexcited field, which will cause the motor to take a lagging current from the line, and an overexcited field, which will cause the motor to take a leading current from the line.

Synchronous motors should not be run with an underexcited field, because they can more easily drop out of synchronism under load and because a lagging current is undesirable.

Synchronous motors are sometimes run with the field overexcited, thus taking a leading current from the line to compensate for a lagging current taken by an induction-motor load. Thus it is possible to avoid paying a power-factor penalty to the power company by keeping the power factor of the combined load as near unity as possible.

Unless the power company has a power-factor penalty clause in the contract, there is no reason why the field current should not be adjusted so that the synchronous motors themselves are operating at unity power factor. This adjustment is made by keeping the field current such that the line current is a minimum when the motor is under load.

Weston A. Brown,
Ohio Power Company.
Philo, Ohio.

## *A Question For Our Readers*

*IF A two-stroke-cycle crankcase-scavenging oil engine can show a full-load fuel consumption of 0.42 lb. per b.hp.-hr. and a mean effective pressure of but 45 lb. per sq.in., why do not the Diesels now using a mean effective pressure of 75 to 90 lb. drop to 45 and thereby better their fuel consumption?*

G. V. M.

Suitable answers (of not over 200 words) will be paid for and published in the Oct. 1 issue.

SYNCHRONOUS motors are designed for operation at 80 per cent leading power factor or unity power factor at full load. The type of motor used and the conditions under which it is used will influence the field excitation required to give the most efficient operation.

When the load is made up almost or entirely of synchronous motors, the unity power factor type is usually installed. In such cases, operating the motors at unity power factor will give the best efficiency at all loads. The field losses can be reduced somewhat by reducing the field current with the field rheostat. When the power factor is decreased below unity the stator current is increased for a given horsepower output, consequently the copper losses in the winding are increased. These losses increase faster than the field losses are decreased, therefore the net result is a decrease in efficiency.

Where two or more motors are excited from a common source, the exciter voltage should be carried as low as possible to give the desired power factor on the motors. If the motors are not identically alike, the exciter voltage should be adjusted to a value that will give the correct power factor on the motor requiring the highest excitation voltage. Then adjust the power factor of the other motors by their field rheostats. When operating under this condition the field resistance will be all cut out on one motor and there will be a small amount of resistance in series with the field of the others. This method of operation allows the minimum losses in the fields of both the exciter and the motors to obtain the desired power factor. If the exciter voltage is made too high, the losses in the field rheostats of the motors may amount to considerable and total up a surprising waste of power in a year. R. O. Brown.
New York, N. Y.

WITH any load condition, the power factor can be adjusted to any value between wide limits by adjusting the field current of the synchronous motor.

If the field current of a synchronous motor operating with lagging line current is gradually increased while the load remains constant, the line current at first decreases to a minimum value and then increases again.

Between the two assumed conditions is a field excitation at which the line current and the line voltage are in phase, that is, the power factor is unity. At this point the line current is minimum, a condition desirable in alternating-current circuits.

Power factors of 0.75 to 1 are in use, although unity power factor is desirable for the most economical operation.

If there is no power-factor meter at hand, the factor can be determined by the use of a voltmeter, ammeter and wattmeter. The power factor is equal to the wattmeter reading divided by the product of the voltmeter and ammeter readings. John M. Moyer.
Lancaster, Pa.

THE field current on the synchronous motors should be adjusted, within the capacity of the synchronous motors, to give a power factor on the circuit nearest to unity.

G. A. Blucher.
Dallas, Texas.

# Lubrication Research Being Made on an Extensive Scale

By A. A. Potter

*Dean of the Schools of Engineering and Director of the Engineering Experiment Station, Purdue University*

BESIDES the studies on lubrication which have been carried on under the auspices of the A.S.M.E. research committee, the following activities are of interest:

*1. N.E.L.A. Prime Movers Committee*—In the Serial Report of the Sub-Committee on Power Station Chemistry for February, 1929, the following conclusions concerning turbine lubrication are given:

The selection of an oil for turbine use must be based upon the fundamental chemical characteristics of petroleum rather than upon the ordinary semi-chemical properties indicated by the tests now in use. What those characteristics will be has not yet been established, but sufficient data are at hand to indicate that suitable tests may be developed.

It is still believed to be a question whether a suitable oil deteriorates in lubricating and chemical quality. Tests have indicated that after a service period estimated as 16,000 hr. no material change is produced in those qualities of the oil usually taken as criteria of fitness. However, during such period of usage certain products develop in the oil, such as sludge, emulsion, water and acidity. Such products may be measured and removed from the oil, and the degree to which they are removed governs the degree to which their development continues. The continued development and removal of such products points to the ultimate consumption of the oil through chemical change. Tests show that the development of these products takes place in cycles, the frequency of which is from four to six weeks, or sometimes longer. Weekly tests are desirable if the true condition of the oil is to be found. The amount of sludge may be determined by observation and photography at 100 magnifications by direct weighing, or by volumetric measurement with the aid of a centrifuge.

Serial Publication 289-28 of the National Electric Light Association gives details of test procedure for determining sludge and emulsion, acidity and viscosity. Regarding the significance of these tests as they apply to the fitness of oils for turbine lubrication the following statement is made:

"The test in the sludging machine is capable of distinguishing between a rapidly oxidizing oil and one that oxidizes at a slower rate. . . . A continued critical study of the changes which oils undergo in this test may reveal the nature of hydrocarbons chiefly responsible for the sludging trouble. . . . The significance of these tests as applied to the use and the testing of oil while in service lies chiefly in the fact that they illustrate how unreliable spot or periodic tests may be when results are used to determine the general condition of the oil. The true condition of an oil in service may be ascertained only by following its changes and the conditions to which it is subjected by sample tests at frequent intervals."

*2. American Society for Testing of Materials*—Report of Subcommittee XI on Turbine Oils is given in Proc. A.S.T.M. *26*, Part 1, 370-380 (1926). Steam-emulsion tests give more concordant results than the Herschel demulsibility text. The Funk sludging machine, which was developed to test out large samples of oil under conditions approximately found in a turbine, is described.

*3. Some Recent Research and Modern Theories of Lubrication*—In the May, 1929, issue of the *Black and White*, a publication of E. F. Houghton & Company, a review of the progress in the theory of lubrication is given. "Boundary," or "solid film," lubrication is given major consideration.

The work of Harkins and Langmuir in this country and that of W. T. Hardy of England leads to the conclusion that the function of a lubricant in boundary lubrication is connected with its absorption at the metallic surface and that this absorption is due to forces which cannot be distinguished from chemical affinity.

A small quantity of fatty acid (1 per cent or less) added to mineral lubricating oil has a marked effect in improving the lubricating power of the oil. The researches on this subject were carried on in the National Physical Laboratory of Great Britain and by Wilson and Barnett in this country. The X ray is needed to study the action of fatty acids in contact with metal plates.

*4. Lubrication Research in Engineering Colleges*—As far as can be determined only the following studies have been made on lubrication:

(*a*) The Pennsylvania State College engineering experiment station is investigating journal bearings. This study is being carried on with a special Kingsbury testing machine, which is designed primarily for determining the fundamental laws of bearing design. The specific problem now in hand is to secure data which will either prove or disapprove the basic assumptions on which the Howarth's graphical charts for bearing design are based. These charts are based upon the hydronamic theory of bearing lubrication of Osborne Reynolds, which has never been confirmed experimentally. The pressure distribution in a bearing at four axial positions is being determined for all angular positions from 0 to 360 deg. F. at the same time that the clearance between the journal and the bearing is measured. Facilities are also provided for measuring oil film temperatures in the bearing and friction loads for various speeds and bearing pressures.

(*b*) The Department of Mechanical Engineering of the Rensselaer Polytechnic Institute is studying the effect of temperature upon the viscosity of oils and oil-gasoline mixtures.

(*c*) The Kansas State Agricultural College engineering experiment station is securing data for the preparation of specifications for lubricating oils.

(*d*) The State College of Washington is making a comparative study of lubricating oils, with special reference to the lubrication of automobile engines.

(*e*) The Iowa State College engineering experiment station is carrying on tests to determine the characteristics of a good lubricating oil.

(*f*) The Department of Chemical Engineering of the Massachusetts Institute of Technology in its publications Serial Nos. 47, 53, 85, 134 and 211 discusses the "Mechanism of Lubrication."

(*g*) The engineering experiment station of the University of Nevada has issued its Bulletin No. 1 on "Comparative Properties of Lubricating Oils made from Nevada Oil Shale."

(*h*) The Cornell University engineering experiment station in its Bulletin No. 5 discusses "Viscometry."

# Ventilation Development Leads to Lower Losses and Temperature Rise

THE opinion of some designers, as well as users, that low temperatures are incompatible with large machines has become well nigh obsolete, according to W. J. Foster and M. A. Savage in a paper presented at the Pacific Coast convention of the A.I.E.E. They are strongly of the opinion that the larger the machine the more conservative the temperature should be.

Some of the largest single-shaft turbine-generators built to date, their report states, have temperature rises, determined by embedding detectors in the stator windings, of 45 to 50 deg. C. instead of 60 deg., and of 60 to 75 deg. C. in the rotor windings instead of 85 deg. as permitted in the contracts. Such machines could be rated about 15 per cent higher and still have temperatures within the usual commercial guarantee in the United States for the largest turbine-generators.

The development of ventilation by means of a large number of multiple paths has been of considerable advantage in building large turbine-generators for speeds of 1,800 r.p.m. and above. With this system a 62,500-kva. generator employing external blowers required practically the same amount of power to ventilate it as a 30,000-kw. previously built. When it is considered that 40 per cent of the loss on a turbine-generator formerly was chargeable to windage, it will be seen that this saving in loss constituted a real step forward in efficiency.

The real value of this change, according to the report, lies in the fact that as far as ventilation is concerned machines of any length can be built, and be as well ventilated as smaller machines if properly designed.

# *Events and Men in Power's Field*

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

## *Spot * News*

PRESENT PLANS *for the New York Hospital and Cornell Medical College Centre, which when finished will cover three city blocks along the East River in New York, call for the erection of a complete steam plant to supply all power services.*

* * *

FOUNDATION WORK *is under way on the new addition to the steam-generating station at Powerton, Ill. Ultimately, two 105,000-kw. turbine-generators will be installed, bringing the total capacity of the plant to 320,000 kw.*

* * *

SALES OF STEAM *by the New York Steam Corporation increased by 579,848,000 lb. during the fiscal year ending June 30, 1929, over the preceding fiscal year, according to a recent announcement of the company. The total for the year was 7,731,487,000 lb.*

* * *

LAYING *of a sixteen-inch welded pipe line is now in progress to transmit natural gas from Jal, N. M., to El Paso, Texas. In the entire 205 miles there will be no bolted joints, the whole line being made into one continuous piece by means of electric welding.*

* * *

THE PROVERBIAL MONKEY WRENCH *literally made trouble in the State Street plant of the United Electric Light Company, Springfield, Mass., when, in the hands of a workman, it crossed a switch and caused a complete shutdown for 43 minutes with from $5,000 to $10,000 damage to the plant. Two workmen were injured, but no fatalities resulted.*

* * *

EXPORTS *of pumps and pumping equipment showed a marked increase during the first half of 1929, when foreign shipments amounted to $3,936,000, a gain of 62 per cent over the corresponding period of 1928. The demand for rotary pumps, especially, rose sharply, according to the Department of Commerce.*

## London Steam Table Conference Praised by George Orrok

### Original Sponsor of American Steam Research Cites Agreement on Standard Values and Tolerances as an Outstanding Accomplishment

AGREEMENT on official steam table values and tolerances at the International Steam Table Conference held in London July 8 to 12 was cited as an outstanding achievement by George Orrok, consulting engineer, in an interview after his recent return to New York. Mr. Orrok, as the prime mover of American steam research for some years past, was a delegate from this country, together with Harvey N. Davis, president of Stevens Institute of Technology; H. C. Dickenson and N. S. Osborne, of the United States Bureau of Standards; and Professor Keenan, of Stevens Institute. President Davis, who has played an outstanding part in American steam research acted as spokesman for the delegation in the formal sessions. Similarly, Germany was represented by Jakob, England by Callendar and Czechoslovakia by Havlicek. Others present were: Samuelson, Robinson, Wedmore, Patchell, Pochobradsky, Davies and Onslow of London; Stoney of Newcastle, England; Knoblauch, Koch and Hausen of Munich; Mollier of Dresden and Miskowsky of Prague.

The harmony and effectiveness of this conference, according to Mr. Orrok, was beyond all expectation. It was truly remarkable, he said, that, in a single session, after two days of informal discussion, the steam investigators were able to agree on exact steam values and tolerances. Mr. Orrok explained that an understanding among the delegates precluded publication of the actual values until the table has received a final check by all those present.

The skeleton table, he said, gives values in steps of 50 deg. and 25 to 50 atmospheres pressure. For each value tolerances are specified with the understanding that any steam table agreeing with the standard within the specified tolerances may be labeled "international."

Dr. Davis invited the delegates to hold the 1930 conference in connection with the celebration of the fiftieth anniversary of the A.S.M.E., while Jakob, speaking for the German engineers, suggested that it be held at Berlin, in conjunction with the World Power Conference.

Following the conference, the American delegates made what might be described as a "steam table tour." They visited the laboratories of Jakob in Berlin, Mollier in Dresden, Havlicek in Mor-Ostrava, Czechoslovakia, and Knoblauch in Munich.

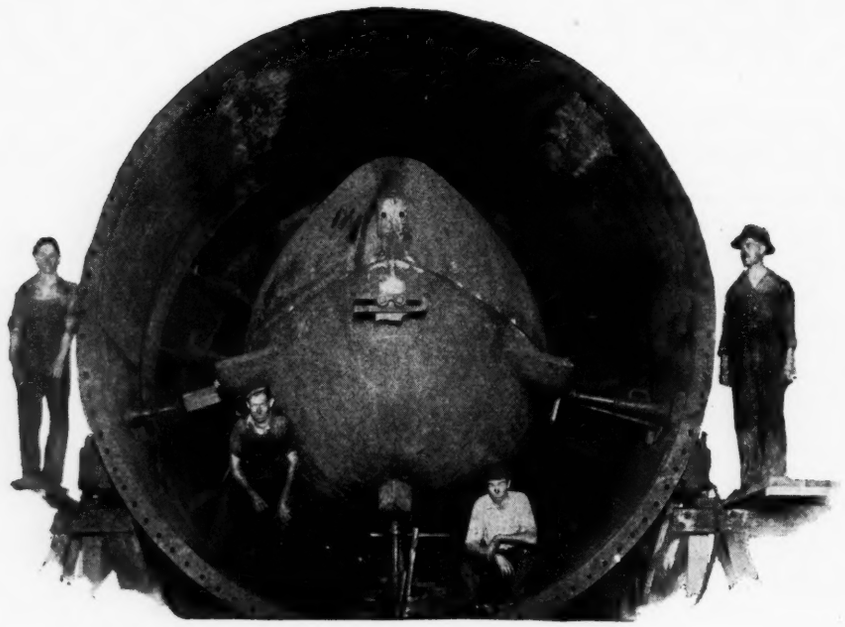
## Aluminum Company to Develop More Power Projects in South

The Aluminum Company of America is starting work on the fourth and fifth units of its hydro-electric development of the Little Tennessee River in Tennessee and North Carolina, at Chilhowee, Tenn., and Nantahala, N. C. The first unit, the Cheoah dam, was completed in 1918, followed by the Santeetlah dam, finished last year. The third unit, the Calderwood high arch dam, is now under construction.

The Chilhowee dam will be a concrete structure of gravity type, 1,500 ft. long and 63 ft. high, situated on the Little Tennessee River about 35 miles south of Knoxville. Headwaters of the Chilhowee reservoir will just reach the Calderwood power house, 10 miles upstream. Flow over the dam will be controlled by twelve Stoney gates 25 ft. wide and 40 ft. high. The power house, adjacent to the dam on the right bank of the river, will contain two reaction-type turbines of 18,000 hp. each, direct connected to 3-phase 60-cycle generators. The power house will contain but one floor, a departure from the usual design. Features of the units will be the use of Kingsbury spherical bearings in place of the flat-plate type, and the introduction of cooling air to the top of the generators instead of at the bottom.

At Nantahala an arch dam 200 ft. high will be built across a narrow gorge of the Nantahala River, a tributary of the Little Tennessee. An unlined tunnel, 12 x 12 ft., will lead from the dam to the power house, 5 miles downstream. The generating unit will consist of a single reaction turbine of 60,000 hp. operating under a static head of 930 ft.

Work will commence at once on the Chilhowee dam, but construction of the Nantahala dam will not be commenced until the completion of the former.



# New Orleans' Mammoth Pumps Soon to Be in Operation

FACILITIES capable of removing from 25,000 to 28,000 cu.ft. of water per second will soon be in operation at New Orleans, La., to pump rain water into the Mississippi River. As New Orleans is below sea level, some artificial means must be provided for getting rid of surface water which, in other cities, drains away naturally.

The new pumps will range in diameter from 14 to 18 ft., and all will be Wood design machines, of the low-head screw type. When driven at its rated speed each of the large pumps will deliver from 1,000 to 1,340 cu.ft. of water per second, according to the varying water conditions. The total pumping capacity ultimately available will be capable of removing in 24 hr. a 14-in. rain over the entire city of New Orleans.

Operation of the pumps will be by General Electric synchronous motors of unusually large size. The seven enormous pumps will each be driven by a 2,000-hp. 6,000-volt motor running at a speed of about 94 r.p.m. The smaller pumps will each be driven by a similar motor rated at 1,200 hp., 6,000 volts, and running at a speed of about 83 r.p.m. A large unit is pictured above.

## Referendum to Be Held on Maine Power Export Bill

AT a referendum to be held Sept. 9, the citizens of Maine will vote on the Smith-Carleton power exportation bill, which passed the last legislature by an overwhelming majority and now awaits the approval of the people to become a law. Under its terms provision is made for the disposal outside of the state of surplus power now going to waste. Ample regulation by the public utilities commission is afforded to protect the state's water power resources from exploitation for the benefit of outsiders.

Opponents of the act claim that Maine will lose all control over power that is exported. If the Smith-Carleton bill becomes a law, however, power can only be sold outside the state by corporations formed for the purpose. These corporations cannot develop any power of their own, but must buy it from domestic companies which, in turn, must secure licenses from the utilities commission in order to sell power for exportation. In securing a license a public utility company binds itself to conform to all conditions laid down by the commission, and must, furthermore, contribute one-half of the income received from this source for rural electrification, besides a 4 per cent export tax.

For the past ten years the development of hydro-electric power in Maine has been hindered by the Fernald law, forbidding water power exportation. Resources which would have yielded large quantities of power at cheap rates if developed on a large scale have been neglected because an outlet for the surplus electricity was lacking. This, in turn, has reacted to keep industry from the state and prevent rapid business expansion.

With the recent decision of the Public Service Commission of New Hampshire authorizing the exportation of power in large blocks from Fifteen Mile Falls on the upper Connecticut River into Massachusetts, Maine becomes the only state in which export of power is prohibited. The opinion is prevalent that this will be changed at the referendum on Sept. 9.

## Brooklyn Edison to Increase Capacity of Hudson Ave. Plant

To meet rapidly increasing load demands the Brooklyn Edison Company has just placed an order for a 110,000-kw. generating unit consisting of a steam turbine, condensing equipment and an electric generator to be installed as the sixth unit in its Hudson Ave. generating station. Manufactured by Westinghouse, the new equipment will be ready for operation in the spring of 1931, it is expected. Four boilers to supply steam for this turbine, equipped with automatic stokers, have also been purchased from the Babcock & Wilcox Company, and will be ready for operation in the fall of 1930, so that test runs can be made.

The new unit will be similar in its main features and equipment to the fifth unit in the same station, which was placed in operation in September, 1928. It will have the same capacity as the previous one, and will be of the cross-compound type. With this installation the capacity of the Hudson Ave. station will be 450,000 kw. When completed the station will have eight generating units, with a total capacity in excess of a million horsepower, making the station one of the greatest concentrations of power anywhere in the world.

## Many Hydro Projects Reviewed by Federal Power Commission

The granting by the Federal Power Commission of the preliminary permit to the Inland Power & Light Company, Portland, to develop 160,000 kw. on the Lewis River in southwestern Washington opens the way for some preliminary work on the part of the company toward the development of its project at the Ariel site, twelve miles above Woodland. Development of the project is planned in four units of 40,000 kw. each. A single dam, about 190 ft. high above normal water level, will create a lake about twelve miles long, impounding approximately 220,000 acre-feet of usable storage. A single power house, designed to be expanded as units are added, will be located immediately below the dam. The dam and first unit is estimated to cost $8,250,000, with the total ultimate cost of the four units without transmission lines estimated at $11,500,000.

The Virginia-Carolina Power Company, of Roanoke Rapids, N. C., has applied to the Federal Power Commission for a license covering a 33,000-hp. development on the Roanoke River, in Halifax and Northampton Counties, North Carolina. It is proposed to construct a dam above Roanoke Rapids at about the location of the existing diversion dam, creating a reservoir seven miles long. Ultimately it is planned to install 55,500 hp. The power is to be sold to the Virginia Electric & Power Company. This application for license applies to one of the developments

covered by the preliminary permit issued the applicant July 10.

The city of Vancouver, Washington, has applied to the Federal Power Commission for a preliminary permit covering a proposed development on the north fork of Lewis River a half mile above the mouth of Swift Creek. It is proposed to install 80,000 hp. The primary power available is 32,000 horsepower.

The commission has authorized the issuance of the preliminary permit to the Washington Electric Company of Seattle covering an initial installation of 72,000 hp. and an ultimate installation of 192,000 hp. on the Columbia River in Chelan and Douglas Counties, Washington. A preliminary permit also has been issued to the Inland Power & Light company, of Portland, covering its 170,000 hp. project on Lewis River. In each of the two cases provisions are to be included in the license, if issued, for the protection of navigation and fish migration.

A transfer of the license issued Walter Cravens on the Osage River in Missouri to the Missouri Hydro-Electric Power Company and the Union Electric Light & Power Company has been authorized.

## Stocks of Bituminous Coal Lowest Point In Many Years

Commenting on the government report of stocks of bituminous coal in the hands of consumers, released by the United States Bureau of Mines recently, the National Coal Association points out that the total quantity of bituminous coal, 33,100,000 net tons, in the stock piles of consumers on July 1, 1929, is the smallest quantity reported since July 1, 1920, except for the period immediately following the long suspension of bituminous coal mining in 1922.

During the summer of 1920 the supplies of bituminous coal in the hands of consumers dropped to a low level and transportation difficulties ensuing a month or so later brought about a severe run-away market for bituminous coal during July, August and September of that year.

Supplies sufficient for twenty days are reported by the railroads. They have in stock only slightly more than one-third of the quantity on hand July 1, 1927, and a little more than one-half of the total held in July, 1928. The report shows that the 33,100,000 net tons of bituminous coal in stocks represents 28 days, supply.

## Unauthorized Publicity to Blame for Power Commission Snarl

No foundation in fact exists for the statement that friction has developed within the Federal Power Commission over the policy to be followed in its accounting system. Whatever concern has been felt has arisen as a result of the misrepresentations and misinterpretations which have grown out of the publicity given the recent opinions made by C. A. Russell, the new solicitor of the Federal Power Commission.

In practically every application which reaches the commission additional information is sought concerning some of the items making up the pre-license costs. In the Cumberland Falls case Solicitor Russell's opinion was intended only as an expression of view on the facts as he understood them. In the ordinary course, when an item is challenged by a member of the commission's staff the memorandum is sent to the applicant, with the idea that he will explain it satisfactory or strike it from the list.

There was no intention on the part of the commission to depart from its practice and its own regulations in the case of the much-discussed Russell opinions. Mr. Russell explained that he discussed the opinions in confidence with a newspaper man, who promptly violated that confidence, and started a controversy which led Senator Couzens to request copies of the opinions. It was he, not the commission, who made them public.

## *Men in the News*

J. R. JEFFREY,

*manager of the electrical department of the Allis-Chalmers Manufacturing Company, Milwaukee, has retired after 28 years of service with the company. His first job was an apprenticeship of two years with the Polson Iron Works, Toronto, on engine and boiler work. He was with the Canadian General Electric Company at Peterboro for six years, becoming chief draftsman after the first year. In 1901 he entered the employ of the Bullock Electric Manufacturing Company, Norwood, Ohio, and after Allis-Chalmers had taken over the Bullock company he was transferred to Milwaukee as assistant manager of the steam and electrical department. In 1914, when the department was divided, he became manager of the electrical department, which position he has since held.*

# News of Canada

*More Data on the Licensing of Engineers in the Provinces—Ontario's Requirements*

By Campbell Bradshaw
*Toronto, Ont.*

THE Ontario act respecting "stationary and hoisting engineers" was revised in 1927, and provides for a board of three examiners, which is responsible for the issuance of all certificates. It stipulates that any person who was the holder of a stationary engineer's license, or who was operating a stationary gas plant, for six months immediately prior to July 2, 1921, shall be allowed to continue in that position without examination, but must qualify and obtain the grade of certificate necessary should he change his position.

Certificates of four grades are issued. To obtain a certificate of the fourth class—the holder of which can operate a plant of 25 to 50 hp.; or operate, under a certificated engineer, a plant of 50 hp. or over, when the safety valves are set so that they cannot relieve the pressure at 10 lb. or less—the candidate must be at least nineteen years of age; have had six months initial operating experience, including at least three months in a boiler room; satisfy the board as to character and ability; pay a fee of $3, and answer the examination questions in such manner as to obtain at least a 60 per cent rating.

The applicant must possess a knowledge of addition and subtraction; be familiar with all types of boilers, how and where they are stayed, the location of tubes, manholes, and handholes; have a thorough knowledge of safety valves, water columns, water glasses, steam gages, blowoff valves, non-return valves, etc., and have experience in the cleaning of boilers and general upkeep of brickwork grates, etc. In addition candidates must be familiar with the operation of injectors and the different types of pumps, particularly boiler-feed, both centrifugal and reciprocating; as well as have knowledge of the care and operation of the plain slide-valve engine. Experience with the different methods of heating boiler feed water, burning fuel, cleaning fires, and "cutting in" and "out" boilers and pipe lines is also required.

Candidates for third-class certificates —which allow their holders to operate stationary steam or gas plants, between 50 and 200 hp., or to operate plants over 200 hp. under a certificated engineer when the safety valves are set so that they cannot relieve the pressure at 10 lb. or less—must be at least 21 years of age; be holders of fourth-class Ontario certificates of the current year, or the equivalent in horsepower in one of the other provinces of the Dominion; have at least two years experience operating steam or gas plants,

with six months in a boiler room and six months in an engine or compressor room; each pay a fee of $5; and obtain at least 60 per cent rating in the examination.

Engineers taking this examination must have a general knowledge of the composition, handling and care of coal and fuel oil; a practical knowledge of combustion, hand firing, and the operation of mechanical stokers and oil-burning apparatus; of the construction of all types of boilers, the parts stayed and why, the care and upkeep of stays, tubes, handhole and manhole joints, fusible plugs, methods of cleaning and keeping clean all parts; of the construction and action of safety valves, water columns, blowoff valves, accessories of boilers; and of keeping brickwork and pipe-work in good repair.

The examination for this grade of certificate includes questions on the following subjects: Methods of setting valves of steam pumps and slide-valve engines; of proper lubrication and the general upkeep of engines; of the lubricating system, governors and throttle valves of steam turbines; of the different types of condensers, where, how, and why they are used; of methods of heating feed water; of the operation and upkeep of generators, motors, switchboards, etc.; together with an elementary knowledge of electricity, of the qualities of oils and methods of treating them, of the different ways of heating and ventilating buildings, of the construction and operation of injectors, boiler feed pumps and other equipment for supplying water to boilers, and of pumps for other purposes than feeding boilers. Intelligent answers must be given to questions relating to the use, care and operation of throttle valves, steam separators, steam traps, expansion joints, reducing valves, sight-feed lubricators and pump lubricators; the operation and machinery used in ice making; the impurities found in water, their effect on boilers and methods of counteracting them; and a sufficient knowledge of arithmetic to enable the candidate to work out any problem involving multiplication and division.

*(Ontario's requirements for obtaining certificates of the first and second class will be published in next week's "News of Canada."*—EDITOR'S NOTE.*)*

## Portable Lightning Generators Used in Transmission-Line Tests

Portable lightning generators for determining whether high-voltage transmission lines are adequately protected against lightning and for making field tests on high-tension lines and insulators have been put in service by both the General Electric Company and the Westinghouse Electric & Manufacturing Company.

Both instruments are similar in principle, and are mounted on trailers. Ordinary 110-volt alternating current is stepped up to 25,000 volts by a transformer in the General Electric apparatus, while current produced by a tractor-driven generator is stepped up to 75,000 volts in the Westinghouse equipment. High-voltage rectifying tubes change the alternating current to the direct current necessary for charging the condensers.

In both designs a large number of condensers are so arranged that they are charged in parallel.. Beginning with an end unit, discharge takes place across a spark gap from one condenser to the net, so that the surge is built up by the whole condenser bank discharging in series. In the ordinary use of the equipment, the 1,000,000-volt charge is impressed directly on the transmission line under investigation.

The effect of this man-made lightning is determined by cathode-ray ocillographs. Both generators were developed so that lightning investigations would not need to be delayed by the vagaries of the natural product in its time, intensity and place of striking.

## Coming Conventions

**American Institute of Electrical Engineers.** Pacific Coast Regional Meeting, Santa Monica, Calif. Sept. 3-6. District meeting at Chicago, Ill., Dec. 2-4. Annual winter convention at New York, N. Y., Jan. 27-31, 1930. F. L. Hutchinson, secretary, 33 West 39th St., New York City.

**American Society of Mechanical Engineers.** Annual meeting at New York, N. Y., Dec. 2-6. Secretary, Calvin Rice, 33 West 39th St., New York City.

**American Society of Heating & Ventilation Engineers.** Annual meeting in Philadelphia, Pa., Jan. 27-30, 1930, at the Benjamin Franklin Hotel. Secretary, A. V. Hutchinson, 33 W. 39th St., New York City.

**American Welding Society.** Fall meeting at Cleveland, Ohio, Sept. 9-13. Secretary, M. M. Kelly, 33 West 39th St., New York City.

**National Association of Power Engineers,** 47th annual convention, Chattanooga, Tenn., Sept. 9-13. Fred Raven, secretary, 417 South Dearborn St., Chicago, Ill.

**National Association of Practical Refrigerating Engineers.** Twentieth annual convention at the William Penn Hotel, Pittsburgh, Pa., Nov. 4-7. Secretary, E. H. Fox, 5707 W. Lake St., Chicago, Ill.

**National Exposition of Power and Mechanical Engineering,** Grand Central Palace, New York City, Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York City.

**New England Water Works Association.** Annual convention at Hotel Eastland, Portland, Me., Sept. 17-20. Secretary, Frank J. Gifford, 715 Tremont Temple, Boston, Mass.

**Third National Fuels Meeting** at the Bellevue-Stratford Hotel, Philadelphia, Pa., Oct. 7-11.

**World Engineering Conference,** Tokyo, Japan, October, 1929. All correspondence should be addressed to the Secretary, World Engineering Conference, Nikon, Kogyo Club, Morunouchi, Tokyo.

# OBITUARY

ROBERT H. ANDERSON, for a number of years connected with the Tennessee Electric Power Company as hydraulic engineer, died suddenly at Blue Ridge, Ga., on Aug. 8, at the age of 52. Up to the time of his death he was actively in charge of the construction of a dam and power development on the Toccoa River for the Toccoa Electric Power Company, a subsidiary of the Tennessee Electric Power Company. Previously he had been engaged at the Great Falls plant of the latter company. As engineer for the J. G. White Construction Company, he did hydro-electric construction work on several important developments throughout the country.

# PERSONALS

R. S. FLESHIEM has been appointed manager of the electrical department of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., succeeding J. R. Jeffrey. L. W. Grothaus, Assistant Manager of the electrical department of the company, has been transferred from the company's Bullock works, at Norwood, Ohio, to Milwaukee, succeeding Mr. Fleshiem.

MAJOR GLEN E. EDGERTON recently ended five years of service as chief engineer of the Federal Power Commission, having been detailed by the Department of War to the United States Military Academy at West Point. He will be succeeded as chief engineer on the power commission by LIEUTENANT COLONEL M. C. TAYLOR, who is now on leave following a tour of duty in the Philippines.

WALLACE S. CLARK, manager of the cable division of the central station department of the General Electric Company, has recently been retired at his own request. F. H. WINKLEY has been appointed manager of the consolidated lighting and cable division. H. V. ERBEN has been appointed manager of the apparatus division of the same department.

W. E. HARRIS, formerly connected with the Stephens-Adamson Manufacturing Company, Birmingham, Ala., has joined the staff of the Charles C. Steward Machine Company, also of Birmingham, and is now in charge of the power-transmission department.

CHARLES C. DAVIS, who has had charge of the construction of the Gorgas Steam Plant, the new 60,000-kw. station just completed for the Alabama Power Company, has been relieved of the duties at that location to permit him to accept a position with the Empire Construction

Company. It is understood that he will be in charge of the Atkinson Steam Plant, which is being built by the Empire Construction Company for the Georgia Power Company.

F. W. DEAN, consulting engineer, Boston, Mass., has been awarded the Dexter Brackett Memorial Medal for having presented to the New England Water Works Association the "most meritorious paper" of those received in 1928, the subject being "Pumping Station Practice."

W. H. BULLOCK, consulting engineer, will serve as chairman of the Denver section of the A.I.E.E. for its new administrative year. N. B. HINSON, assistant manager of the operating department, Southern California Edison Company, will serve as chairman of the Los Angeles section. DR. L. N. ROBINSON is the new chairman of the Seattle, Wash., section and EARL BAUGHN, of the engineering department of the Washington Water Power Company, will preside over the Spokane, Wash., group. The Utah section will have A. C. KELM, distribution engineer for the Utah Power & Light Company, as chairman.

## BUSINESS NOTES

GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has announced that, effective Oct. 1, 1929, the fourteen wholesale distributing corporations owned by the parent company will be consolidated into the General Electric Supply Company (of Delaware). No change of ownership is involved in the combination, but the consolidated company will be able to render nation-wide service from 76 houses, with the advantage of interchangeability of stocks.

UNIVERSAL POWER SHOVEL COMPANY have moved from its location at 15841 Second Boulevard, Detroit, Wis., to its new plant at Milwaukee, Wis. Executive offices are now located in the Bankers' Building, Milwaukee.

NEILAN, SCHUMACHER & COMPANY, Los Angeles, Calif., are establishing sales representation in Chicago and New York. J. M. Coffeen will become sales representative in Chicago. The New York representative has not yet been announced.

DODGE MANUFACTURING CORPORATION, Mishawaka, Ind., announces the appointment of E. S. Grant, formerly assistant general sales manager in charge of the New York district, as general sales manager.

SHEFFLER-GROSS COMPANY, Philadelphia, Pa., announces that M. Scheffler and Samuel Gross have purchased a substantial interest in the newly organized Delaware County Heating Company. This company will operate the plant formerly owned by the Springfield Heat Company, located at Springfield, Delaware County, Pa.

WAGNER ELECTRIC COMPANY, St. Louis, Mo., announces that Ralph R. Rugheimer is now a member of the Atlanta branch sales office.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY announces that I. F. Baker has recently been appointed European sales manager of the Westinghouse Electric International Company. He will have his headquarters at 2 Norfolk St., Strand, London. Mr. Baker was formerly sales manager of the power department of the international company.

## TRADE CATALOGS

WATT-HOUR METERS—"Registers of Revenue" is the title of booklet C-1753-A, recently released by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. A discussion of the history of watt-hour meters, the requisites of such a meter, and a description of the types manufactured by Westinghouse are featured in the publication.

CHAINS AND CONVEYORS—The new Catalog and Engineering Data Book, No. 330, published by the Chain Belt Company, Milwaukee, Wis., contains 800 pages of information on chains and chain drives, elevators and conveyors, traveling water screens and construction machinery. A special section upon the application of such equipment to power plants is of decided interest. The book is illustrated with several hundred photographs of specific installations of Chain Belt Company and Sterns Conveyor Company equipment.

LUBRICATION — The Standard Oil Company of Indiana discusses the problem of lubrication of refrigerating machinery in its engineering bulletin R-79. Previous to the discussion of lubrication problems, a review of the various types of refrigerating machines and refrigerants is given. Photographs and drawings aid in presentation of the information.

PUMPING EQUIPMENT—The waterworks system of Toronto, Ont., particularly the pumping equipment, is portrayed in a leaflet recently released by the De Laval Steam Turbine Company, Trenton, N. J. Illustrations of several of the fourteen De Leval Pumps installed in the system are given. The De Laval steam turbines which drive some of these units are also described.

DIESEL ENGINES—A complete history of the municipal Diesel engine power plant, at Bryan, Texas, both from its technical and economic aspects, is treated in a booklet published by the Busch-Sulzer Brothers Diesel Engine Company, St. Louis, Mo. In addition to a description of the equipment, statistical charts showing the cost of producing power are of interest.

COMPENSATORS—Ten illustrations of automatic compensators and controllers in service under difficult conditions are shown in a recent folder put out by the Electric Controller & Manufacturing Company, Cleveland, Ohio. Special problems encountered in installing automatic motor control in particularly adverse locations is discussed.

## FUEL PRICES

### COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

| Bituminous (Net Tons) | Market Quoting | Price per Ton |
|---|---|---|
| Navy Standard | New York | $2.00 @$2.35 |
| Kanawha | Columbus | 1.25 @ 1.55 |
| Smokeless | Cincinnati | 1.85 @ 2.00 |
| Smokeless | Chicago | 2.25 |
| S. E. Kentucky | Chicago | 1.35 @ 1.60 |
| Steam | Pittsburgh | 1.55 @ 1.65 |
| Gas Slack | Pittsburgh | 1.00 @ 1.10 |
| Big Seam | Birmingham | 1.50 @ 1.75 |
| **Anthracite** (Gross Tons) | | |
| Buckwheat | New York | $2.50@$2.75 |
| Barley | New York | 1.40@ 1.50 |

### FUEL OIL

**New York**—Aug. 22, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75@5.25c. per gal.; 36@40 deg., furnace, tank-car lots, 6c. per gal.

**St. Louis**—Aug. 13, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.4209 per bbl. or 42 gal.; 26@28 deg., $1.4709 per bbl.; 28@30 deg., $1.5209 per bbl.; 30@32 deg., $1.5709 per bbl.; 32@36 deg., gas oil, 4.276c. per gal.; 38@40 deg., distillate, 5.23c.

**Pittsburgh**—Aug. 20, f.o.b. local refinery, 30@34 deg., fuel oil, 4.5c. per gal.; 36@40 deg., 5c. per gal.

**Philadelphia**—Aug. 18, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 22 deg. plus, $1.575@$1.625 per bbl.; 23@27 deg., $2.10@$2.15 per bbl.

**Cincinnati**—Aug. 20, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5.25c. per gal.; 30@32 deg., 5.5c. per gal.

**Chicago**—Aug. 9, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 65c. per bbl.; 26@30 deg., 85c. per bbl.; 30@32 deg., $1.00 per bbl.

**Boston**—Aug. 19, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.35c. per gal. 28@32 deg., 5.2c. per gal.

**Dallas**—Aug. 10, f.o.b. local refinery, 26@30 deg., $1.30 per bbl. or 42 gallons.

# *New Plant Construction*

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

**Calif., Los Angeles**—C. E. Cooper, 5466 Wilshire Blvd., is having preliminary plans prepared for a 30 story apartment building on West 6th St. Estimated cost $3,500,000. K. MacDonald, Spring Arcade Bldg., is architect.

**Calif., Los Angeles**—Needlecraft Building Co., c/o A. Curlett, Union Bank Bldg., Archt., is having plans prepared for a 12 story mercantile building at Wall, Los Angeles, 7th and 9th Sts. Estimated cost $3,500,000.

**Conn., New London**—Southern New England Ice Co., 75 Howard St., had plans prepared for the construction of an ice manufacturing plant on Howard St. Estimated cost to exceed $40,000. Private plans.

**D. C., Washington**—D. C. Commissioners, received lowest bid for remodeling power plant at Gallinger Hospital from Rust Engineering Co., District National Bank Bldg., $38,850.

**Ill., Chicago**—Commonwealth Edison Co., 72 West Adams St., awarded contract for masonry, etc., for an electrical distribution station 4650 Lincoln Ave. Estimated cost $25,000.

**Ill., Chicago**—A. S. Alschuler, Inc., 28 East Jackson Blvd., Archt., will soon receive bids for the construction of a 7 story department store at 63rd and Green Sts. for Wieboldt Department Store, Milwaukee and Ashland Aves. Estimated cost $2,000,000.

**Ill., Chicago**—J. T. Wheeler, 120 South La Salle St., awarded contract for masonry, etc. for a 16 story apartment building including refrigeration system, etc. at Maple and Sale Sts. Estimated cost $1,500,000.

**Ia., Des Moines** — Burton Building Co., B. Joseph, Pres., will build an 18 story office building at Locust and 6th Sts. Estimated cost $2,000,000. Proudfoot, Rawson, Souers & Thomas, 810 Hubbell Bldg., are architects. Work will be done under the supervision of Arthur Sanford & Co., Equitable Bldg.

**Mass., Allston** (Boston P. O.)—Homeopathic Hospital, G. S. Glidden, Chn. of Bldg., Comn., 531 Tremont St., is having plans prepared for the construction of a group of hospital buildings including nurses' home, power house, etc. at Commonwealth Ave. and Washington and Warren Sts. Estimated cost $6,000,000. Kendall, Taylor & Co., 209 Columbus Ave., are architects.

**Mass., Boston** — New York, New Haven & Hartford R.R. Co., Union Ave., New Haven, Conn., awarded contract for the construction of a boiler house on Fargo St. here to Tredennick-Billings Co., 10 High St., Boston. Estimated cost $40,000. E. Gagel, is chief engineer.

**Mass., North Reading** — Dept. of Public Health, awarded contract for the construction of an admitting and isolating building including power house at State Sanitorium. Estimated cost $175,000.

**Mass., Woburn** — Edison Electric Illuminating Co., 39 Boylston St., Boston, is receiving bids for the construction of an electric transformer station. Bigelow, Wadsworth, Hubbard & Smith, 11 Beacon St., Boston, are architects. Whidden-Beekman Engineering Co., 250 Stuart St., Boston, is engineer.

**Mo., Columbia** — City, J. S. Bicknell, Clk., awarded contract for addition to power plant to Simon Construction Co. Estimated cost $69,900.

**N. J., Hillsdale** — Dept. of Institutions & Agencies, Trenton, will receive bids until Sept. 6, for the construction of a 40 x 80 ft. power house at New Jersey State Hospital here. Estimated cost $150,000.

**N. J., Paterson**—Bd. of Chosen Freeholders, Court House, will receive bids about Sept. 15 for the construction of an 8 story detention jail and hall of records building including steam heating system, etc. at Grand and Spring Sts. Estimated cost $1,000,000. H. B. Crosby, 125 Ellison St., is architect.

**N. Y., Hornell**—New York Central Electric Corp., plans the construction of a new substation $100,000, also new 110,000 v. power line from Montour Falls to Hornell.

**O., Akron**—Central Savings & Trust Co., 12 East Mill St., will soon award contract for the construction of a 24 story bank and office building at Main and Mills Sts. Estimated cost $2,000,000. Walker & Weeks, 2341 Carnegie Ave., Cleveland, are architects.

**O., Akron**—DeWitt Hotel Co., c/o T. DeWitt, V. Pres., c/o Hollenden Hotel, Cleveland, plans the construction of an 18 story hotel at Main and State Sts. Estimated cost $1,500,000. Graham, Anderson, Probst & White, Railway Exchange Bldg., Chicago, Ill., are architects.

**O., Cleveland** — Cleveland Electric Illuminating Co., Public Sq., awarded contract for a 1 story, 50 x 80 ft. condenser house on West 95th St. to Hunkin-Conkey Construction Co., Hunkin-Conkey Bldg. Estimated cost $40,000.

**O., Dayton**—Constructing Quartermaster will receive bids until Sept. 4 (extended date) for the construction of a boiler house.

**Okla., Oklahoma City** — Oklahoma Gas & Electric Co., Insurance Bldg., is having plans prepared for the construction of a steam turbine power plant, 30,000 kw. capacity at Belle Isle Park. Estimated cost $750,000. Byllesby Engineering Co., 231 South La Salle St., Chicago, Ill., is engineer.

**Okla., Seminole**—City is having preliminary plans prepared for the construction of a Diesel engine power plant. Estimated cost $60,000. R. N. Geer, is engineer.

**Pa., Neville Island** (mail McKees Rock)—Manufacturers Light & Heat Co., 248 4th Ave., Pittsburgh, is receiving bids for superstructure of a 36 x 155 ft., compressor building here. Estimated cost $40,000. Columbia Engineering & Management Corp., Pittsburgh, is engineer.

**Pa., Philadelphia**—Monarch Realty Co., c/o Heymann and J. Greenberg, Fidelity-Philadelphia Bldg., awarded contract for a 23 story office building, etc. at 1616-26 Walnut St. to Wark Co., 1600 Walnut St. Estimated cost $3,000,000.

**Pa., Philadelphia**—Ritter & Shay, Packard Bldg., Archts., will receive bids until Sept. 12, for the construction of a 20 story bank and office building at Market and Juniper Sts. for Market & Juniper Building Corp., c/o A. M. Greenfield, Bankers Trust Bldg. Estimated cost $2,500,000.

**Tex., Amarillo** — American Commonwealth Corp., New York, and Texas Utilities Co., Amarillo, are having preliminary plans prepared for a 15,000 kw. additional unit to power plant here. Estimated cost $1,500,000.

**Wis., Sparta**—State Bd. of Control, Madison, awarded contract for the construction of a 94 x 118 ft. power house for State Public School to L. G. Arnold, Eau Claire.

**Ont., Windsor**—Hutton & Souter, 6 James St., S. Hamilton, Archts., are receiving bids for addition to hotel including steam heating system, etc. for Norton Palmer Hotel.

## Equipment Wanted

**Conveying Equipment**—Nickel Plate Elevator Co., G. Schmitt, Pres., 6420 Grand Ave., Cleveland, O., is in the market for conveying equipment for proposed new warehouse.

**Engines and Generators**—Dept. of Welfare, H. H. Griswold, Dir., 9th and Oak Sts., Columbus, O., will receive bids until Sept. 16 for two engines and two generators complete, 125 kw. each, for Dayton State Hospital, Dayton.

**Heating Plant Equipment** — Bd. of Regents, University of California, Berkeley, Calif., will receive bids until Oct. 7, for furnishing and installing mechanical equipment for central heating plant.

**Pump**—City of Hollis, Okla., 150 g.p.m. centrifugal pump against 160 ft. head, 120 hp. oil engine and generator for proposed waterworks improvements.

**Pump, etc.** — City of Upland, Calif., E. C. Mehl, Clk., plans to purchase a 150 in. booster pump, etc. for waterworks.

**Pumps**—Mountain View School District, El Monte, Calif., will receive bids until Sept. 5, for furnishing and installing a 3,000 g.p.m. turbine water pump.

**Pumps** — Sewage and Water Board, New Orleans, La., will receive bids until Oct. 16, for pumps, etc. for proposed waterworks improvements.

**Pumps, etc.**—City of Tecumseh, Okla., pumps, etc. for proposed waterworks improvements. Estimated cost $126,000.

**Pulverizing Units** — Dept. of Institutions & Agencies, Boston, Mass., plans to purchase steam turbine driven coal pulverizing units for Long Island Hospital. Estimated cost $50,000.

**Stoker** — Bd. of Trustees, Ohio State University, C. E. Steeb, Secy., Columbus, O., will receive bids until Sept. 19, for a 600 hp. stoker.

**Transformers, etc.**—A. L. Flint, General Purchasing Officer of the Panama Canal, Washington, D. C., will receive bids until Sept. 6, for transformers, etc.

## Industrial Projects

**Calif., Los Angeles**—BATTERY FACTORY—Willard Storage Battery Co., 1601 South Hope St., plans the construction of a storage battery plant on 9th St. Estimated cost $500,000. C. Beelman, 1019 Union Bank Bldg., is architect.

**Ill., Chicago** — RADIO FACTORY — Temple Corp., 1925 South Western Ave., awarded contract for the construction of a 1 and 2 story factory for the manufacture of radio receiving sets and speakers at La Vergne Ave. and West 65th St., to Foltz & Co., 510 North Dearborn St. Estimated cost $500,000.

**Ind., Indianapolis** — TANK FACTORY — Tokheim Oil Tank Co., 1602 Wabash Ave., Fort Wayne, is receiving bids for a 2 story, 30 x 800 ft. factory. Estimated cost $100,000. Pohlmeyer & Pohlmeyer, Central Bldg., Fort Wayne, are architects.

**Mich., Grand Rapids** — BODY FACTORY — Hayes Body Corp., 551 7th St., N. W., is having plans prepared for a 3 story, 75 x 565 ft. factory on Muskegon St. Estimated cost $125,000. Private plans. Electric motors and conveyor system, etc. for handling bodies will be required.

**Mo., St. Louis** — CHEMICAL PLANT — Vestal Chemical Co., T. J. Polinow, Pres., 215 Pine St., will receive bids about Sept. 5, for the construction of a 3 story, 60 x 120 ft. chemical plant at Manchester St. near Kingshighway. L. Haeger, 3844 Utah St., is architect.

**Mo., St. Louis**—DISPLAY FIXTURE FACTORY—Multiplex Display Fixture Co., 918 North 10th St., awarded contract for a 2 story, 96 x 105 ft. factory to Huger & Buecker, 801 Wainwright Bldg.

**N. J., Newark**—AUTOMOBILE FACTORY—Packard Motor Car Co., Broadway and 61st St., New York, N. Y., awarded contract for a 3 story, 200 x 206 ft. factory at 637-43 Central Ave. here to John W. Ferguson Co., 152 Market St., Paterson. Estimated cost $300,000.

**N. J., West New York**—HOSIERY MACHINE MANUFACTURING PLANT—Alfred Hofmann, Inc., 635 15th St., is receiving bids for the construction of a 2 story, 100 x 125 ft. plant at 629-35 15th St. Estimated cost $50,000. Lockwood Greene, Inc., 1 Pershing Sq., New York, are architects and engineers.

**O., Cleveland** — METAL STAMPING FACTORY — Dill Mfg. Co., G. D. Williamson, Pres., 694 East 82nd St., plans the construction of a 1 story factory on Mandalay Rd. Estimated cost $150,000. Architect not selected.

**O., Dayton**—STEERING WHEEL FACTORY—Inland Mfg. Co., Coleman Ave., awarded contract for the construction of a 1 story, 250 x 600 ft. factory for the manufacture of steering wheels to Hillsmith & Co., Winters Bank Bldg. Estimated cost $500,000.

**Pa., Beaver Falls** — STEEL SPECIALTY FACTORY — Standard Steel Specialty Co., awarded contract for the construction of a 1 story, 60 x 120 ft. factory on West Mayfield St. to Penn Bridge Co., College Hill. Estimated cost $75,000.

**Pa., Brackenridge** — MIRROR FACTORY — Liberty Mirror Co., 6615 Kelly St., Pittsburgh, awarded contract for a 1 story factory on South Railroad St. here to Blaw Knox Co., Blaw Knox. Estimated cost $160,000.

**Pa., Philadelphia**—SODA FOUNTAIN FACTORY—C. E. Wunder, 1520 Locust St., Archt., will receive bids until Sept. 5, for the construction of a 1 and 2 story, 375 x 480 ft. factory at Erie and F Sts. for I. Fishman & Son, 10th and Allegheny Sts. Estimated cost $1,500,000.

**Tex., Lamesa**—MILK PLANT—Douthitt Engineering Co., et al., plan the construction of a milk plant. Estimated cost $200,000. Owners will build.

**Ont., Delhi**—TOBACCO PROCESSING PLANT and POWER PLANT—Imperial Tobacco Co., 3810 St. Antoine St., Montreal, Que., is having plans prepared for the construction of a plant including power plant equipped with Diesel engine, etc. here. Estimated total cost $175,000.

**Ont., Simcoe** — CAN FACTORY — American Can Co., will soon award contract for a 2 and 3 story, 100 x 150 and 100 x 250 ft. factory on Norfolk St. Estimated cost $1,000,000. Private plans.